BRIEFING BY NATIONAL BUREAU OF STANDARDS

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OF MICHIGAN

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READING ROOM

HEARINGS

BEFORE THE

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BRIEFING BY NATIONAL BUREAU OF STANDARDS

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
Washington, D.C., Thursday, May 7, 1959.

The committee met at 9:30 a.m., Hon. Overton Brooks (chairman of the committee) presiding.

The CHAIRMAN. The committee will come to order.

We are a little rushed this morning because the House is meeting at 10 o'clock, but we are very anxious to hear at least one witness. I realize it is an imposition on the members to set a committee meeting at 9:30, but we had no alternative. We can't run over the 10 o'clock period because there is going to be a vote on an important bill. I believe everybody will want to be present over there at that time.

This morning—before I get into this morning's schedule, my colleague, Mr. Karth, handed me an article by Mr. John Norris, staff reporter for the Washington Post. It refers to the Air Force setting a goal of 16 or 17 Atlas squadrons instead of the goal of 7 or 8, as I recall, which they told our committee they would need. That means a stepping-up of their quota for the Atlas, 100 percent greater than they told our committee they were interested in. It is an important development. I don't know to what extent it involves this committee, but I am going to ask some member of the staff to look into this and to see whether or not we should talk to anybody about it, whether or not we should put something in the record to indicate the changes there in their needs.

The Bureau of Standards is with us this morning. Dr. A. V. Astin is Director. He will be the only witness we will hear this morning, but we have Dr. H. Birnbaum, Assistant to the Director, and Mr. R. S. Walleigh, Associate Director for Administration, Dr. A. T. McPherson, Associate Director for Engineering, Mr. Norman Christeller, Budget Officer, and Mr. Bourne Upham, Deputy General Counsel, Department of Commerce.

Now, Dr. Astin, we are happy to have you. This is the first time that our committee has been able to schedule witnesses from the Bureau of Standards which is a very, very important part of the U.S. Government, and I think legislatively it is a part that has been overlooked to some extent.

I have been here a number of years. I live right next to the Bureau of Standards and although I have been in Washington over 20 years, I have never been in the Bureau of Standards.

I am afraid others are in the same shape. We don't know the type of work that you are doing. We know that it must be pretty good because we would have heard complaints before this had it not been at a high level.

Therefore, Doctor, do you have a prepared statement?

Dr. ASTIN. No, sir; I do not. I am not sure just what it was you wanted.

The CHAIRMAN. We want a complete rundown of the operations of the Bureau of Standards. We would first like to have your background so the committee may become acquainted with you.

Dr. ASTIN. Very good, sir.

The CHAIRMAN. And then a rundown of the program of the Bureau of Standards and any suggestions or recommendations you would like to make.

STATEMENT OF DR. A. V. ASTIN, DIRECTOR OF NATIONAL BUREAU OF STANDARDS

Dr. ASTIN. Well, I am a native of the State of Utah, was born in Salt Lake City, educated in the public schools there, and received my bachelor's degree in physics from the University of Utah in 1925.

The CHAIRMAN. Mr. King tells me you are one of the outstanding sons of Utah. He is from Salt Lake City.

Dr. ASTIN. I know that. I know Mr. King's family, and I am very proud of my native Utah background.

I then went to New York University, where I received a master's degree in physics in 1926 and a Ph. D. in physics in 1928.

From there I went to the Johns Hopkins University in Baltimore, where I spent 2 years as a National Research Council fellow in physics.

Following this, I came to Washington to the National Bureau of Standards, working on an industrial research program which was financed by the Utilities Research Commission of Illinois. This program lasted for 2 years, and following this I secured a position on the staff of the National Bureau of Standards and have been there ever since; so I have spent practically my entire professional career at the organization with which I am now associated.

I was appointed to the position of Director of the Bureau of Standards in 1952 by President Truman. The mission of the National Bureau of Standards is a very basic and important one for the Nation's scientific and industrial progress. Our responsibilities are prescribed by statute and have been basically unchanged since the organization was established in 1901.

However, the content and scope and complexity of our work has changed considerably over this period of 58 years. The statute assigns to us six functions according to the revision made in our statute in 1950, and these are as follows:

First, we have responsibility for developing and maintaining the standard for physical measurement. Next we are authorized to determine important physical constants and properties of materials. Then we are to work on methods of testing and evaluating materials, mechanisms, and structures.

Fourth, we are to cooperate with other Government agencies and private organizations in developing standard practices, such as codes and specifications.

Fifth, we are to render scientific and technical advisory services to other Government agencies.

Sixth, we are authorized to perform specific development activities for other agencies of the Government.

Our first three functions all deal with the problem of measurement, and this begins with providing the standards for physical measurement. A standard for physical measurement is much like the oldest standard of all, namely, language.

Languages are means of communicating between individuals. In the same way a standard of physical measurement permits the communication of scientific and technical information among scientists and engineers.

Almost all scientific and engineering endeavors are concerned with efforts to measure the properties of things and events. Now these measures of the properties of things or events must be expressed in numbers, and the numbers must be referred to a standard in order that they will have meaning from one laboratory to another.

Similarly, the whole of commerce is involved in the exchange of goods, which requires agreement as to the amount exchanged, and this must be referred to a standard of some sort if orderly exchange is to be brought about. There is another phase of this interchangeability which has assumed increasing importance in our economy, particularly over the past 50 years, and this is the concept of interchangeable parts.

Our mass production industry is based essentially on the ability to fabricate a component or part so that it will conform to some predetermined physical characteristic. In order to assure that the component matches these required characteristics, there must be measurement techniques and standards to which the measurements can be referred in order that the interchangeability which is the essence of our mass production can take place.

Another aspect of this is that our economy has been built to an appreciable extent upon specialty manufacturing, and one cannot have this specialty manufacturing operate effectively unless there are measurement techniques and measurement standards so that one manufacturer is able to secure components from another manufacturer with the assurance that these will fit into whatever assembly he is concerned with.

So this whole fabric, first of the interchangeability of information among scientists and engineers, the interchangeability of components in industry, the exchange of goods in commerce, all rests basically on standards for physical measurement.

Now, a standard by its very nature is only as good as the accuracy with which it can be reproduced. This means that the organization concerned with providing the standards for physical measurement must excel in techniques of measurement. Otherwise, we impede the opportunity for this important exchange. Hence, we must, in order to fulfill our function of providing the standards together with means for their effective utilization, have the utmost competence in techniques of physical measurement.

This competency which we must have to do this first job is really responsible for our second statutory function, that of providing precise data on the properties of materials when these are of importance to science and industry and are not available elsewhere.

Hence we have a rather extensive program seeking to accumulate on a systematic basis important properties of materials to aid the work of scientists and engineers throughout our economy.

In addition, the work on the properties of materials and the provision of the standards requires, as I have stressed, competence in physical measurement. We are able to provide considerable assistance to industry, to scientists, and to other Government agencies, on the utilization of accurate measurement techniques. Measurement techniques are fundamental to a great deal—well, to practically all of our scientific and industrial development because these are the techniques by which we learn about the properties of nature. Consider one of the most glamorous aspects of modern science, namely these earth satellites that your committee and, in fact, the whole United States are extremely interested in. Basically, these satellites are merely instrument observation platforms beyond the screen of the earth's atmosphere. When we put a satellite beyond the screen of the earth's atmosphere, we can make observations on phenomena coming from the entire universe with instrumentation which is provided in the satellite.

I think if one similarly analyzes most other scientific or engineering phenomena, we find it boils down to some achievement of scientific measurement.

Another quite different phenomenon which many of you have heard a great deal about in recent years is automation. Automation consists for the most part in an ability to measure and control automatically the properties of goods being produced. A great element in the advances in automation has been brought about by advances in instrumentation techniques and, at the same time, things which limit the extension of automation are largely problems in instrumentation which haven't been solved.

Well, I wanted to take a few minutes to emphasize the importance of measurement and instrumentation because this is part of science and engineering which is most closely associated with the basic responsibilities of the National Bureau of Standards.

Now, in addition to our basic concern with the problem of measurement first in establishing the standards, then in techniques for utilizing the standards, then in using the measurement techniques for the systematic accumulation of data, we have other very important responsibilities.

As an organization which began with seeking to achieve competence in the techniques of physical measurement, it was natural for other Government agencies to come to the Bureau for scientific and technical assistance. I think one of the first instances of this occurred over 50 years ago when the Bureau was asked for assistance first on building materials which went into the House Office Building and also into examining cables for elevators in the Washington Monument. These were the beginnings of an extensive program of providing specialized technical services to the rest of Government.

The largest and most important of these is our Central Radio Propagation Laboratory which was established as a result of developments and problems which arose during World War II. Our Central Radio Propagation Laboratory seeks, first of all, to accumulate, analyze, and disseminate, on a systematic basis, information on the properties of the earth's atmosphere which affect the transmission of radio waves. We have a program in many respects much like that of the Weather Bureau in accumulating data on the electrical properties of the earth's

atmosphere and then in analyzing these, distributing the information and making forecasts of the most probable communication conditions for some time in the future.

In addition, associated with this program, we have an extensive effort on research into the properties of the earth's atmosphere which affect long-range radio communication. Our group at the Central Radio Propagation Laboratory played a very important role in the International Geophysical Year and had the major responsibility for the IGY's observations upon the ionosphere.

Another central service function which we are performing for Government is in the area of utilizing advances in modern electronic computing techniques to aid the work of other Government agencies. This program also had its beginning as a result of developments in World War II, and began with a request from the Census Bureau to assist in seeing if the World War II advances in electronic computation techniques could be developed to a stage where they would assist the Census Bureau in the processing of census data. The Census Bureau's request was soon coupled with the requests from the Army Map Service and the Air Comptroller. This led to a design study contract and later a procurement contract, which in turn resulted in the first three Univacs which were produced. From this beginning we accumulated a rather large and quite competent group. We built a machine of our own to provide internal assistance to the organization in applying these modern computational tools to the solution of other technical problems and we now have a rather extensive program of providing assistance to other agencies of the Government in the utilization of these techniques.

The Congress gave us authorization and funds a few years ago to construct a large-scale pilot data processing machine which we hope to complete this year, and this will be used to make pilot studies on the data computational problems of other Government agencies.

A third area where we provide general technical assistance to other agencies of the Government is in the field of building technology and fire research. This program goes back many years, but here we seek to develop information on the properties of building materials and building structural techniques and assist other Government agencies in applying this information to their advantage in their carrying out their construction responsibilities.

These data are also of considerable importance to the general public, and we have a number of publications in this area which are widely used by the construction industry.

A fourth general service area is in the field of cryogenic engineering. This facility is located at Boulder. It originated about 9 years ago in response to a request from the AEC in connection with its problems in handling and utilizing liquid hydrogen.

As the AEC's interest in liquid hydrogen changed, it offered to turn the facility over to us, which at that time was the largest liquid hydrogen plant in the world, and laboratories associated with it if we would operate the facility in the general interests of Government in accumulating information on the properties of materials at very low temperatures and on techniques for handling materials at very low temperatures.

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One aspect of this program which I think is quite interesting is that our people in cooperation both with the Bureau of Aeronautics of the Navy and the Bureau of Mines have shown that the most efficient and economical way to transport helium is not in these large massive pressure cylinders which you are probably familiar with, but in liquid form in specially designed Dewar flasks, a Dewar flask being a specially insulated device, much like a thermos bottle only much more advanced.

Well, now I think these things illustrate the general nature of the Bureau's program. It is summed up in two ways. First, we seek to provide for the country the central basis for a system of uniform measurement throughout science and industry in the United States, and second we operate central technical service facilities in designated areas of science or technology.

Now, to carry out these programs we have a staff of approximately 3,300 people, most of whom are located in Washington, but there is a group of close to 900 people at Boulder, Colo., doing our work at the Central Radio Propagation Laboratory, the cryogenic engineering laboratory, and our radio standards laboratory.

We have a number of small field stations, most of which are associated with the work of the Central Radio Propagation Laboratory.

Of our staff of 3,300, approximately 1,450 are professional scientists and engineers. Administratively, we subdivide our program into 17 technical divisions. For the most part, the subject matter of these divisions corresponds to traditional subdivisions of science and technology among the professional scientists and engineers.

For example, there is an electricity and electronics division, a mechanics division, an atomic and radiation physics division, and a metallurgy division, and so on.

Since our program is set up primarily to provide an essential service to the Nation's scientific and engineering community, we are most interested in developing techniques to assure that we are working on the most relevant and important problems to the scientific and engineering community. To help us in optimizing or maximizing our program, we have asked the National Academy of Sciences-National Research Council to establish advisory committees in various areas of science and technology.

These advisory committees, to an appreciable extent, represent the scientific and engineering community. They meet with our people, provide suggestions on ways and means to carry out the work, and assist us in selecting those activities which are most important to their work and in the area of our statutory responsibilities.

In addition, the law provides for a visiting committee of five outstanding experts who report annually to the Secretary of Commerce on the efficiency of our operations and the condition of our equipment.

This visiting committee consists at the present time of Dr. Mervin J. Kelly, recently retired as president of the Bell Telephone Laboratories as chairman. Dr. Kelly is a physicist and electronic engineer by training.

Then next is Mr. Crawford Greenewalt, who is a chemist by training, and now president of the Du Pont Co.

Next is Dr. Detlev Bronk, president of the Rockefeller Foundation for medical research and also president of the National Academy of Sciences.

Then there is Dr. Lloyd Berkner, president of Associated Universities and recently president of the International Council of Scientific Unions.

And Dr. Fred Seitz, an outstanding solid state physicist, professor at the University of Illinois, and until recently chairman of the governing board of the American Institute of Physics.

In addition to the visiting committee, the Secretary of Commerce from time to time has established ad hoc groups to take a rather penetrating overall look on the operations of the National Bureau of Standards in relation to present national needs.

One such study was made by an ad hoc committee in 1953 and there is now a present study of a similar sort going on, but this study applies to all of the scientific programs of the Department of Commerce, not just to the National Bureau of Standards.

Mr. MILLER. Mr. Chairman, we may be called away shortly and I think it would be interesting if you would tell us how the Director of the Bureau of Standards is selected.

Dr. ASTIN. Well, the law requires that the Director of the National Bureau of Standards is appointed by the President, by and with the advice and consent of the U.S. Senate.

Mr. MILLER. From a panel of names submitted?

Dr. ASTIN. No, there is no provision for this, although various Secretaries use different techniques. Mr. Charles Sawyer was Secretary of Commerce at the time I was selected, and he asked the National Academy of Sciences to submit to him a list of eligible candidates for the vacancy which had been created by the resignation of Dr. Condon, and a special committee was established by the National Academy, and it submitted to Mr. Sawyer a group of names.

I understand mine was among them, and Mr. Sawyer then recommended to the President my name for this position. I am not familiar with techniques used for my predecessors.

Mr. MILLER. I know in your case it was entirely nonpolitical. You didn't know your name was on the list, I believe, until you were approached.

Dr. ASTIN. That is correct.

Mr. MILLER. I just wanted to get that on the record.

The CHAIRMAN. Mr. Anfuso.

Mr. ANFUSO. I would like to ask you this: Will this new Space Agency, for example, exploring other planets, new stars, uncountable millions of miles away, will that require new methods or standards for measuring distances and weighing material?

Dr. ASTIN. Well, this particular area, and it is really no different from problems in other areas of science, has two characteristics.

First of all, there is a continual pressure to increase the accuracy of measurement in all pertinent fields. Then there are requirements to extend measurement techniques into the frontiers of science.

For example, the space age as well as the atomic age have increased substantially the requirements for measurements at very high temperatures.

Now this is what I mean by extending the frontiers. Our techniques for measuring temperatures above about 4,000 degrees Fahrenheit are very sketchy, and there is a tremendous need to improve our measurement techniques in this area and to establish a reliable temperature scale for these measurements.

Now, at the same time, the problems in instrumenting space vehicles brings pressures for miniaturization, which in turn brings pressures to measure minute lengths ever more accurately, and we are now seeking to answer a request of American industry to provide length calibrations good to one ten-millionth part of an inch. Does that answer your question?

Mr. ANFUSO. Yes, it does answer my question.

Does this bring you into contact with other countries where you must establish international agreements?

Dr. ASTIN. Yes, sir. There is an international organization called the International Bureau of Weights and Measures located at Sevres, just outside Paris, which was established by the Treaty of the Meter of 1875. The primary purpose of this was, through the metric system, to promote uniformity in measurement techniques throughout the world.

The United States ratified that treaty in 1878 and we have been one of the supporters of that organization ever since.

Mr. ANFUSO. And where is the main headquarters of that organization?

Dr. ASTIN. At Sevres, just outside Paris.

The CHAIRMAN. I am going to interrupt here because we have just had a call for a vote on the floor, but I would like to ask you to do this, Dr. Astin. I know you won't be able to be here tomorrow, but I think the committee will be interested in this information and, of course, other information.

We would like to have information on the size of your budget and the breakdown of the distribution of funds on the budget for the Bureau of Standards.

I think you made an excellent dissertation on the work of the Bureau of Standards, but you have not given us any recommendations.

Dr. ASTIN. That is correct.

The CHAIRMAN. And we would like very much to have your recommendations.

Dr. ASTIN. Thank you.

The CHAIRMAN. We would like to get a rundown on the question of what progress we are making to standardize our weights and measures throughout the world and, as my colleague from New York has referred to, what is needed in the way of new measurements or new standards of measurement. For instance, you referred to heat, speeds, things of that sort.

In addition to that, we would like to know what progress you are making in the liquid hydrogen program. I understand they are now moving hydrogen by vessel to England, something on that program, and on your pilot study programs, and what you would recommend as to any additional function or operation that the Bureau of Standards might need in this new era we are going into, which is the space era.

Now if you could—I am not going to ask for the answering of those questions now, it would take too long and we don't have much time. Mr. Fulton wants to ask you about one particular project, though, which I understand can be answered in just a minute.

Mr. FULTON. Well, that can be done later.

The CHAIRMAN. Would you rather do it now or later?

Mr. MILLER. Will the gentleman yield? I would like to make an observation. I have been familiar with the Bureau of Standards and I have one complaint to make about them. They are too modest. Dr. Astin hasn't told you of the great contribution that they made in the atomic energy field. It is one agency that I don't think has a public relations man on their staff and, therefore, we don't hear about them and half of the things they do, somebody else grabs on to and comes out and says "Look what we have done in the development of this," and the real work has been done right in the Bureau of Standards.

The CHAIRMAN. They do an amazing job, I am sure. One more thing I would like to put in my suggestions.

Several years ago a recommendation was made to the Armed Services Committee that the vibrations on Connecticut Avenue were such that it interfered seriously with your work. At that time it was recommended that you obtain a different location. Now we would like for you to cover that, too, if you will, tomorrow.

We will meet tomorrow at 10 o'clock.

Mr. Fulton.

Mr. FULTON. I wanted to have put in the record a statement on the cooperation with the programs of other nations as well as the method of exchange of scientific information and also translating which has been done.

Secondly, the possible use of counterpart funds for that purpose, and then the point that I wanted to ask as to a project is this: The problem comes up between two systems of measurement that are already established. One is an earth system of measuring distances and time, and the second is in astronomy, the system of measuring distances and of measuring time.

I would like to put in a resolution that is a method of integrating those two systems by distance, for example. If we could take the first area in the year 2000 so we could have 2 times 10 to the third power, or maybe we could take 2 billion years ago, 5 times 10 to the ninth power, to try to get a point in time and distance that will relate these tremendous distances and times to our earth system of measurement.

Would you think of that, and I will talk to you further about it.

Dr. ASTIN. Yes.

The CHAIRMAN. Thank you very much, and the committee will recess until 10 o'clock in the morning.

(Whereupon, at 10:14 a.m., the committee recessed until 10 a.m. Friday, May 8, 1959.)

BRIEFING BY NATIONAL BUREAU OF STANDARDS

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
Washington, D.C., Friday, May 8, 1959.

The committee met at 10 a.m., Hon. Overton Brooks (chairman of the committee) presiding.

The CHAIRMAN. I call the committee to order. This morning we have a number of witnesses we will be delighted to hear from. We have Mr. Norman L. Christeller, Budget Officer, who will discuss the fiscal status of the Bureau, the relocation and new facilities and personnel. Mr. Christeller, do you have a prepared statement, sir?

STATEMENT OF NORMAN L. CHRISTELLER, BUDGET OFFICER, NATIONAL BUREAU OF STANDARDS

Mr. CHRISTELLER. I have some notes, sir, from which I can speak. Before I begin my statement this morning I might pass on to you an additional comment which Dr. Astin realized that he had overlooked yesterday morning. That is, that he wishes to extend to any or all committee members a cordial invitation to visit the laboratories of the Bureau, either those on Connecticut Avenue or those in Boulder, Colo. We would be delighted to demonstrate for you some of the current work of the Bureau. As a layman myself I can assure you that you would find such a visit very fascinating.

I might say, sir, that we have several charts which I believe are before each committee member from which I will speak concerning the budget situation of the Bureau. We are very sorry that due to the shortness of time we were unable to have prepared statements for each of the witnesses this morning but I hope the charts will be helpful. I will try to cover the budget information as quickly as possible and then having provided some administrative information turn to two of our associate directors, Dr. A. T. McPherson, and Dr. I. C. Schoonover, who will present some comments on the current state of technology as they relate to the Bureau's programs.

Dr. McPherson will speak specifically on the methods by which the Bureau disseminates the standards of physical measurement throughout the national technology and will present some information concerning the current national needs in that area of our responsibilities.

Dr. Schoonover will comment on some of the other needs of science and technology and the Bureau's plans for meeting those needs. Finally, Dr. Henry Birnbaum, an assistant to the Director, will discuss our international programs.

We hope, Mr. Chairman, that this presentation will assist the committee in this initial review of the National Bureau of Standards, and, of course, we are at your disposal and shall be happy to attempt to

provide any additional information which the committee members should desire.

I have provided you with four tables which I believe may be helpful in summarizing the current budgetary situation. Table I is a summary of the total NBS program. Because this total program is financed from several diverse sources, we have prepared the table in terms of those sources of support.

Under Federal sources we list, first, our direct appropriation which in fiscal year 1959 is approximately $12½ million and which is budgeted in 1960 at $17½ million.

The Bureau has for a number of years provided also a variety of research and development services for other agencies of the Federal Government. During the current fiscal year this program financed by other agency funds consists of approximately 600 individual projects. The total cost is estimated at about $16½ million. I shall return to this matter of services for other agencies in a moment.

Going on with the table, the Bureau also provides calibration services to other agencies in order to assure that their instruments are consistent with the national standards and to assure that their measurements are interchangeable. The calibration program for other agencies is estimated at about $1 million this fiscal year. It shows a considerable increase over previous years due to the activation last summer of the Electronic Calibration Center at our Boulder, Colo., laboratories to serve the needs of the Department of Defense for calibration of electronic instruments.

Under non-Federal sources we list first the calibration program which is estimated at slightly more than half a million dollars this fiscal year. This is similar to the calibration program I just described for the Federal agencies. I might add that the Bureau does have authority to finance the cost of this service by retaining the fees paid by the industrial and university groups which request the various calibration services.

The CHAIRMAN. What does that amount to per year—the fees?

Mr. CHRISTELLER. The fees this year are estimated at $560,000. This program is showing a gradual increase as industrial concerns find need for more calibration assistance. Dr. McPherson will speak to this in a moment.

We also list the gift program which consists of special research and development projects and projects closely related to the Bureau's primary program which interested industrial and research organizations desire to see accelerated. That is listed at $139,000 this fiscal year.

Then, finally, under the technical program we have listed the sale of standard samples. These are samples of materials whose composition or characteristics have been precisely determined and certified by Bureau scientists. They are used by industrial organizations, universities, and other research organizations to calibrate scientific instruments or to control quality on the production line. In this case also, the fees paid by the recipients of the standard samples are retained by the Bureau to cover the cost of production. The estimated sales this fiscal year amount to $206,000.

For completeness in this summary, I have included the various aspects of our nontechnical program such as our plant and facili-

ties program, which consists of minor improvements and construction items, additions to laboratories, and major equipment items. We have also included the "Construction of facilities" appropriation which refers to the funds provided for detailed architectural design of our new Bureau facilities, and we have included a reference to the cost for which we are reimbursed from the Diamond Ordnance Fuze Laboratories in the joint use of administrative facilities. The Diamond Ordnance Fuze Laboratories are our next door neighbors, having previously been a part of the Bureau. They are now a part of the Department of the Army and we find it both convenient and economical to share administrative facilities, such as technical library and plant repair and maintenance with this organization.

Mr. MILLER. Where is it located?

Mr. CHRISTELLER. It is located on the Bureau grounds on Connecticut Avenue. It was formerly a constituent part of the Bureau.

Mr. MILLER. The Bureau developed fuzes during World War II, is that correct?

Mr. CHRISTELLER. That is correct.

Mr. MILLER. Now, is the Army taking over that program?

Mr. CHRISTELLER. That program has been transferred to the Department of the Army. It was transferred in fiscal year 1954.

Mr. MILLER. But you work close together.

Mr. CHRISTELLER. Yes, we do a considerable amount of work for them.

Mr. MILLER. You developed the proximity fuze?

Mr. CHRISTELLER. This was one of the developments at the Bureau during the war; yes.

Mr. MILLER. I would like to point that out to my colleagues because you hear a great deal about the arsenal complex and the arsenal system of doing things as against turning it over to so-called private industry. The proximity fuze was perhaps one of the greatest developments. I don't have to tell you people that. But this was developed by Government scientists working at Government facilities. That is good to remember.

The CHAIRMAN. The Bureau of Standards, specifically.

Mr. MILLER. The Bureau of Standards specifically, yes.

The CHAIRMAN. Now, let me ask you this: The property on which this is located, is that a part of the Bureau of Standards since or has that property been transferred to the Department of Defense?

Mr. CHRISTELLER. The property has not been transferred to the Department of Defense because the buildings are jointly occupied—partly by our groups, partly by Army people.

The CHAIRMAN. So for expansion purposes they are still your buildings.

Mr. CHRISTELLER. They are still our buildings, except that I think it is evident that the program is so important that we could not displace the fuze development program that is occupying the building.

The CHAIRMAN. Now, was that transferred by legislation or by executive order?

Mr. CHRISTELLER. It was transferred by an executive order.

The CHAIRMAN. The buildings themselves which they occupy are still your buildings?

Mr. CHRISTELLER. That is right, sir, although at some point if we can work out an arrangement in terms of which buildings could be completely occupied by them, such a transfer might then take place to them, since the buildings don't meet our needs at the present time.

The CHAIRMAN. Would that take legislation?

Mr. CHRISTELLER. I believe that the legislation that now exists would be adequate because the General Services Administration can arrange for transfer between agencies—transfers of real property.

The CHAIRMAN. Thank you, sir.

Mr. MITCHELL. Mr. Chairman.

The CHAIRMAN. Mr. Mitchell.

Mr. MITCHELL. Mr. Christeller, who is responsible for the maintenance of this portion that is occupied by the Army? Is that in your budget?

Mr. CHRISTELLER. To the extent that we can assist them in providing maintenance we do so, but they reimburse us for the cost of that maintenance. On this table I, it is the third from the bottom item, $1,123,000.

Mr. MITCHELL. Thank you.

Mr. CHRISTELLER. With this quick summary of the total program which, for 1959, is estimated at $36 million, I would like to turn to table II, which summarizes the programs under the Bureau's research appropriation. The individual entries in this table represent the various divisions into which the Bureau is divided organizationally. I think a review of these division titles will indicate the wide scope of the Bureau's programs which involve us in most of the fields of the physical sciences.

The Bureau's appropriation request for fiscal year 1960 involves a sizable increase which is needed to make progress toward three primary objectives. The first of these objectives is illustrated by table III, which shows the relationship between work supported by Bureau appropriations and work supported by other agencies. Two points should be noted. First, chart 1 on this table indicates that in terms of direct man-years of technical effort, which is really the best method we have of comparing from year to year how much work we are able to perform—in terms of direct man-years of technical effort, throughout the past 9 years, in which we have seen large-scale advances in technology and widespread advancement of scientific frontiers, the program supported by Bureau appropriations has actually been below the level which was supported in 1950.

In other words, just when the requirements for our services to science and technology have expanded in scope and increased in complexity, our ability to meet those demands has been below the level which pertained 10 years ago. The fiscal year 1959 program almost returns the Bureau to the 1949–50 level and the fiscal year 1960 budget should put the program just above that level. Table III also indicates the predominance of other agency programs. Since 1949 the major part of the Bureau's technical effort has been devoted to work for other Government agencies. This has been recognized by the Bureau and by many advisory and reviewing groups as a diversion from the principal mission of the Bureau. This has meant that the Bureau has been dependent upon other agencies to support a prin-

cipal part of its staff. It has also meant that much of the Bureau's effort was channeled away from its basic activities to research and development work related to the mission of other agencies. It has meant that the Bureau programs have been relatively unstable, depending as they do on coordinate support from other agencies.

Mr. MILLER. Mr. Chairman.

The CHAIRMAN. Mr. Miller.

Mr. MILLER. What is this peak that took place in 1953? You started in 1949.

Mr. CHRISTELLER. That is the peak in connection with the ordnance work the Bureau was doing in both fuze development and some early work in some of the missile development programs, and the buildup occurred due to the rapid advances that were being made during the 1950, 1951, 1952 period, and then the dropoff is because of the transfer of these programs to the Department of Defense.

Well, in view of these problems——

The CHAIRMAN. Was that due to the Korean war? Was that the reason for the step-up?

Mr. CHRISTELLER. That was certainly one of the reasons for the step-up during that particular time; yes, sir.

Mr. MILLER. When the chips were down, the Department of Defense had to turn to you as the scientific agency for assistance?

Mr. CHRISTELLER. I believe that is a fair statement.

Mr. MILLER. You may not make it, but I will.

Mr. CHRISTELLER. Well, I have mentioned this because it is one of the management problems of the Bureau—this large other agency program. It, for instance, hinders our long-range research planning and has in fact diverted attention so that certain areas which are basic to the Bureau's responsibilities have suffered from neglect.

To deal with these problems and to achieve a proper balance in our program, the Bureau has consciously limited the expansion of other agency work to only the most urgent projects and has attempted to offset by reduction elsewhere such expansions as were unavoidable. In recent years a portion of each appropriation increase has been devoted to the conversion of other agency work to NBS programs.

In fiscal year 1960 almost one-third of the proposed increase in the Bureau's appropriation would be expected to be programed to permit the conversion of other agency programs to Bureau support or the diversion of Bureau staff from terminating other agency jobs to basic NBS responsibilities.

A second objective that is reflected in the 1960 budget relates to the critical need for expanding Bureau effort in several areas of science and technology. I will not attempt to provide details concerning these needs because I believe Dr. McPherson and Dr. Schoonover will take care of that matter.

The third objective toward which the 1960 budget is an important step is that of modernization of the Bureau's research equipment. Progress in modern science depends on the newest available equipment, equipment which although costly, we find pays for itself in greatly improved scientific output and a better use of technical personnel. In our laboratories, which are expected to provide basic data and measurement techniques for use by all other research and technologolical organizations, the lack of adequate and modern research equipment is a serious handicap.

This handicap has resulted for a number of reasons. First of all, increased precision in measurement cannot ordinarily be met without better equipment and more elaborate measurement systems. Secondly, the advance of science and technology into new fields and the consequent entry of Bureau measurement and standards research into those fields has generated a need for more equipment often of a completely novel type. Also increased sophistication of equipment to provide greater sensitivity and precision often increases the complexity and hence the cost of the equipment. Finally, these problems—of need for more equipment and equipment of greater complexity—these problems have been compounded by the general price inflation which we all know about.

The problems of ordinary obsolescence are therefore accentuated by extraordinary conditions which are inherent in the Bureau's primary programs.

The Bureau's equipment problem is never going to be completely solved. There will always be a need for new and more complex equipment in order to stay at or near the forefront of science and technology. It is important, however, that the Bureau take steps to reduce the size of the problem as it exists today and attempt to keep pace with the demands in the future.

The Bureau has therefore proposed that $1,275,000 of the 1960 budget increase be allocated for the purchase of capital equipment.

The CHAIRMAN. What will that consist of?

Mr. CHRISTELLER. Such items as mass spectrometers, spectroscopes, a variety of specialized research equipment, for example.

This item does not include any major individual items of equipment, but rather a collection of items in the range of from $5,000 to $60,000 or $70,000 each, in all of our laboratories. Each of these places is in need of this sort of thing.

Mr. HECHLER. Mr. Chairman.

The CHAIRMAN. Dr. Hechler.

Mr. HECHLER. Could we get a complete list of that for the record?

Mr. CHRISTELLER. I would be happy to supply a list of the types of equipment we are proposing in this budget; yes.

(The information requested is as follows:)

The following is a list of representative items of equipment required to carry out NBS research programs in 1960:

Optics and Metrology Division: Interferometer and related instrumentation for light-wave length standards		$45,000
Heat Division:		
Induction furnace	$25,000	
Photoelectric pyrometer	88,000	
Pulsated power supply	85,000	
		198,000
Atomic and Radiation Physics Division:		
High resolution vacuum spectrograph	66,000	
High-temperature black body	20,000	
Plasma physics discharge tube and data recorder	52,000	
Soft X-ray and electron spectroscope	75,000	
		213,000
Electricity and Electronics Division:		
Heavy current shunt	20,000	
Volt-box setup	18,000	
Gas capacitor	12,000	
Nuclear magnetic resonance equipment	25,000	
Cole bridge and cells	15,000	
		90,000

Data Processing Systems Division:		
Analog-to-digital converter	$5,000	
Microwave oscillators	6,000	
Function generator	4,000	
Digital voltmeter	5,000	
		$20,000
Radio Standards Division:		
RF power sources	30,000	
Spectrum analysis	80,000	
Noise source	10,000	
Attenuation standard setup	50,000	
HF high power generator	30,000	
LF high power source	10,000	
Impedance bridge	9,000	
Polarad EMF signal sources	29,000	
Field intensity meter	20,000	
		268,000
Chemistry Division:		
Vacuum HT crystal melting apparatus	22,500	
Scanning spectrometer	30,000	
Induction furnace	6,000	
High-resolution spectrograph	15,000	
Time-of-flight mass spectrometer	15,000	
		88,500
Organic and Fibrous Materials Division: X-ray generator		11,000
Metallurgy Division:		
Vacuum melting unit	$7,500	
Gas analysis unit	9,000	
Recording oscillograph	5,000	
Metal evaporator	5,000	
Micro-focus X-ray equipment	12,000	
Auxiliaries for electron probe	7,000	
Stress rupture units	15,000	
		60,500
Mineral Products Division:		
Controller and programer—resistance furnace	6,000	
Viscometer and plastometer	4,500	
Dilatometer	8,000	
Mass spectrometer	58,000	
		76,500
Mechanics Division: Hydraulic press		40,000
Building Technology Division:		
Controlled atmosphere furnace	$10,000	
Induction furnace	10,000	
Mass spectrometer	25,000	
		45,000
Radio Propagation Engineering Division:		
Analog-to-digital converter	6,000	
RF wattmeter	5,000	
Digital recording system	9,000	
12-Channel FM recording system	17,000	
Spectrum analyzer	15,000	
Infrared spectrometer	12,000	
HF transmitters	12,500	
		76,500
Radio Propagation Engineering:		
Frequency counter	3,000	
Generators	8,000	
Power supplies	20,000	
Voltage regulators	12,000	
		43,000
Total		1,275,000

Mr. CHRISTELLER. Well, finally, for a complete record of the budgetary situation I have provided——

The CHAIRMAN. Before we get off that, that one and a half million, will that buy you down to date on your equipment needs?

Mr. CHRISTELLER. This will make a major step toward improving our equipment situation.

The CHAIRMAN. What else do you need?

Mr. CHRISTELLER. We would anticipate a continuing need in subsequent fiscal years, although these items would have to be related to the particular programs that we undertake in each of those years.

In addition, I will refer in a moment to the major new items of equipment that are needed and which are being planned in connection with our new laboratories.

The CHAIRMAN. I see.

Mr. CHRISTELLER. I have included table IV which summarizes our "Plant and facilities" appropriation. I don't believe I need to go into detail. It includes two major items. The purchase of several radio propagation field sites as authorized in Public Law 85-890, which was enacted during the 2d session of the 85th Congress. It also includes the funds for the addition of one wing to the Bureau's main laboratory building at Boulder, Colo.

With this review of the Bureau's current fiscal status, I might mention the situation with respect to the use of counterpart funds.

As you know, the authority to use counterpart funds was enacted by the Congress last summer, to use them for research purposes, that is. Except for supplemental appropriation at that time for agricultural research and scientific information activities, no counterpart funds have yet been appropriated for research purposes.

The executive branch is engaged in discussions at the present time concerning the research and scientific information activities for which counterpart fund appropriations will be requested.

The CHAIRMAN. How would you use them?

Mr. CHRISTELLER. Well, the Bureau believes that this is an excellent use of counterpart funds and would provide a very worthwhile extension of our research efforts. We have been reviewing the possibilities of research in the various countries in which the counterpart funds are available and we have identified a large number of individuals and institutions which appear to us to have the capability to assist us in specific research programs. We would, therefore, enter into contracts with those institutions and individuals for specific research projects.

Mr. MILLER. And in these countries the counterpart funds are available.

Mr. CHRISTELLER. To be conducted in those countries, that is right.

Mr. MILLER. In France you might enter into a contract with some university to give you some specific——

Mr. CHRISTELLER. Yes, sir, the situation in France—we know of a lot of scientists in France who could assist us. There is a very small amount of counterpart funds available in France unfortunately. Other countries have larger amounts and we have been surveying the possibilities in those countries, too.

Mr. MILLER. You are cognizant of the fact that in Belgium the Air Force has a staff that is working with foreign universities, that they have been very successful in some of this work? They have worked, I know—they have let contracts even with the University of Israel and have used a number of very fine European scientists there.

Mr. CHRISTELLER. Yes, we are. We also have a number of possible programs that we would conduct in Israel and a number of other countries where the funds are available.

The CHAIRMAN. Have you investigated the possible use of agricul-cultural funds?

Mr. CHRISTELLER. Yes, these counterpart funds that are available to us are those arriving from the sale of agricultural surplus.

The CHAIRMAN. That is an unusual program. Other counterpart funds are available through foreign aid. Tell me this: Where is your trouble? Is it lack of interest on the part of our Government or is it lack of interest on the part of local governments overseas?

Mr. CHRISTELLER. I wouldn't say that there is trouble at this point, sir. It is the problem of getting a program of this nature organized and into operation.

The CHAIRMAN. Well, do you need any legislation on it?

Mr. CHRISTELLER. I don't believe that legislation is needed. I believe there is adequate legislation.

The CHAIRMAN. You need something on it.

Mr. CHRISTELLER. All of the agencies engaged in research are dealing with this problem to work out the best method for handling this program and I believe that it will be starting in the near future.

I might add that we look forward to this cooperative use of the research competence of the scientists of other nations as a real opportunity to further the performance of our own responsibilities.

I might summarize this description of the Bureau's budgetary situation by commenting that one of the greatest problems of the Bureau is to try to cover, with our limited resources, all of the standards, measurements, properties, and materials assistance which scientists and engineers in all fields of science need. It is obvious that we must set some priorities on those needs. It is not always as obvious how one might determine the priorities. To assist in this we do have the benefit of several advisory committees established by the National Academy of Sciences and perhaps also we can find assurance that the highest priority programs will be emphasized because of the pressure of the competition among the programs for allocation of necessarily limited resources.

Turning to another matter, in addition to the budgetary tables, I have provided for the committee a summary of Bureau personnel, indicating the numbers and the various categories. I believe that this information requires no additional comment unless the committee members have specific questions.

I might add, however, in connection with the personnel situation, the Bureau did receive during the past year authorization for 15 of the so-called scientific supergrade positions; that is, the ungraded positions for which rates of pay ranging from $15,000 to $19,000 are authorized.

Turning then to our facilities——

Mr. MILLER. Before you get away from that, under other professionals, not being too specific, but briefly would you tell us what a few of these jobs may be?

Mr. CHRISTELLER. Metallurgists, electronic scientists, smaller groups that didn't seem to warrant a breakout.

Mr. MILLER. That is enough. Thank you.

Mr. HECHLER. Mr. Chairman.

The CHAIRMAN. Mr. Hechler.

Mr. HECHLER. Do you have any difficulty recruiting personnel when you have vacancies?

Mr. CHRISTELLER. Recruitment is a continuing problem of the Bureau which has bothered us for some time. I think that Dr. Astin is hoping to have an opportunity to discuss this with the committee sometime in the future, but I might say that one of our problems is that we find it particularly difficult to recruit high quality new Ph. D.'s just finishing their graduate work, because they find more attractive opportunities elsewhere.

One of the things we find is that if we can get them to the Bureau for a while they will find the programs very stimulating and many of them will then decide to stay with us. Even so, they look to the situation in the Bureau and they see problems in terms of limitations on future opportunities in the Bureau and we also have a turnover problem among the new people.

Mr. HECHLER. I wonder if you would give us for the record the extent to which you utilize any National Science Foundation facilities for locating personnel and any suggestion that you might have for improving the whole process of identification and recruitment of scientific personnel.

Mr. CHRISTELLER. We will be happy to supply a complete statement. I might say that we do have an arrangement of cooperation with the National Research Council of the National Academy of Sciences in which we establish postdoctoral research associateships and are able to bring in 10 to 20 well-qualified individuals to do special research jobs with us each year. We have found in bringing them in for the research associateship that in many cases we can then build up an interest in them in staying on the permanent staff of the Bureau.

Mr. HECHLER. Well, I might say another reason I asked the question was to appraise the adequacy of the national register that the National Science Foundation is endeavoring to build up, and whether you can give them any tips as to how it could be improved.

Mr. CHRISTELLER. We will be happy to.

(The information requested is as follows:)

The National Science Foundation register of scientists and engineers has been assembled for use in possible national emergencies. The register would be used for mobilization purposes and to locate special competence needed to meet specific emergencies. The register is therefore not available to Federal agencies as a source of information for personnel recruitment.

The primary source of recruitment of scientists and engineers for NBS laboratories is the universities of the Nation. The National Research Council postdoctoral research associateships have therefore been a welcome recruiting aid both by bringing in well-qualified Ph. D.'s and by acquainting university researchers and graduate students with the varied NBS research programs.

Mr. MILLER. If my colleague will bear with me, I will recite a little incident.

Some years ago a young lady just graduating from the University of California, a very smart girl—she had put herself through college on a series of scholarships, having specialized in mathematics—she wrote to me wanting to get a job in Washington.

I called up Dr. Brode, a good friend of mine, Associate Director. He said we get lots of these applications. A week later he called me up

and said, "I want this young lady." Eventually she came back and worked for the Bureau. She subsequently got a scholarship at the University of Chicago to get her master's and is now teaching out in California. That summer I happened to be on the committee and we were out visiting some of the airplane plants. We were discussing personnel and I told this to the executive director of an aircraft company and he called me aside on the way out and he said, "You know that girl you were talking about?"

I said, "Yes."

He said, "We would like to get hold of her."

He didn't know a thing about her. I said, "She is with the Bureau of Standards."

He said, "I will pay her $50 a month more than they are paying."

I said, "How do you know what she is worth?"

He said, "It doesn't make any difference. Whatever she is worth to the Bureau of Standards, she is worth $50 a month more to me."

So that is the trouble with the Bureau of Standards and in the Government, holding people.

Now, I may say that raiding the Bureau of Standards by this method was not just a question of money entering into it with this airplane company in this case, because the Federal Government was paying on almost a cost-plus basis the salary of this girl had she gone out there with them. It didn't make any difference to them. They could give her $50 a month more. It was all our money that was being spent.

Mr. HECHLER. Mr. Chairman, I don't want to get too far away from the purpose of this hearing this morning except that I noticed in this morning's paper the case of this fellow who used to work with Wernher von Braun in Germany who was found washing dishes up in Canada. Obviously our net cannot capture people who are washing dishes up in Canada, yet I think there may be some ways we can improve our identification and utilization process for scientific talent.

The CHAIRMAN. We are calling that to the attention of the proper authorities right now.

Mr. CHRISTELLER. I might concur in some of the statements by saying that we do have a lot of NBS alumni throughout the country and we think that we have provided a training ground for a great many of the research chiefs and vice presidents for research of industrial firms throughout the country.

The CHAIRMAN. What is your total personnel, Mr. Christeller?

Mr. CHRISTELLER. It is 3,430 at the present time, sir. I might turn now, with your permission, to the question of facilities for the Bureau. A major problem encountered by the Bureau in recent years in connection with our attempts to improve the performance of our basic responsibilities relates to the status of the physical plant of the Bureau. The laboratories and administrative offices in Washington, D.C., are at the present time housed in 94 buildings on a 68-acre tract which, as you know, is in the center of residential Northwest Washington. This site has been occupied by the Bureau since 1903. Of the 94 buildings, 31 are of permanent construction, 30 are semi-permanent, and 33 are temporary. Many of these buildings are outmoded and inefficient for use as laboratories for modern research and

we find them quite expensive to maintain because they require frequent repairs and improvements.

Of the two-thirds of the buildings on the principal site which are temporary or semipermanent, many were built during emergency periods and were hastily constructed wherever space and utilities would permit. These buildings were not planned to be permanent units of the Bureau, but the continuing demand for Bureau services compels their continued use. The average age of the temporary buildings is 12 years and almost all require an unusual amount of maintenance and repair. If the Bureau were not to be relocated, at least a dozen of these buildings would require replacement during the next few years.

The Bureau also faces very serious difficulties with respect to utilities and laboratory services. Although the electrical distribution system and mechanical facilities have been rehabilitated during recent years, this has merely served to make up for long deferred maintenance. It has not been possible to correct the basic deficiencies in the utilities and facilities services.

The utilities, as they are now provided, are inadequate and the problem is aggravated by a continual growth in, for example, the electric load because of the increases in the equipment needs of the modern research programs.

In fact, one of the limiting factors at the present time in some of our new programs is the heavy utility requirement associated with the new research equipment. Similar situations exist with respect to the usefulness of the limited space available to the various research programs.

The physical plant of the Bureau has not kept pace with the increase in responsibility and the growth of the technical programs. Because of the more or less haphazard additions to the physical plant, many closely related research activities have been housed in widely separated locations. It has become difficult to provide effective management for Bureau research under these conditions. At the present time the average technical division is housed in eight different buildings. We have one division that has space in 17 buildings. Such a dispersal of technical operations results in difficulties of supervision and coordination of project work and in a loss of effective interchange among projects in the various fields of the physical sciences.

The Bureau management has considered regrouping many of these activities within the Bureau grounds. On the present site, however, it is not practicable to make a complete and proper resettlement and the justification for making the very large expenditures for complete regrouping is extremely questionable because the great inadequacy of many of the present buildings would merely result in a regrouping that would move some programs to less adequate facilities than they now have.

Regrouping and rearranging of facilities are to be expected in a dynamic research program. Under present conditions such changes are often impossible. At the very least they are extremely expensive because of the inflexibility and the outmoded condition of our facilities.

The CHAIRMAN. What do you recommend on that?

Mr. CHRISTELLER. We are working on the problem, sir, and I will try to review the current status of it. It has been very important that new and better facilities be provided which will be easily adaptable to changing research conditions. It is also essential then that the Bureau facilities be moved to a less populous area. When the Bureau moved to the present site it was sufficiently removed from other activities so that its program could be conducted without interference from the surrounding neighborhood, but since 1903 the city has grown up around the installation and the Bureau is now in the center of a very heavily populated area.

This has resulted in restriction on the research use of the site. In many cases we have had to spend additional funds to develop special equipment and protective measures to avoid interference with the surrounding community.

These conditions which I have attempted to summarize indicate clearly, we believe, the need for new Bureau facilities. The gross inadequacies of the present facilities have been subject only to makeshift solutions, temporary structures, additions to buildings, patchwork renovations, and the Bureau is now at the point where significant corrective action must be taken.

The newly recognized importance of science to our military, space, and industrial programs merely serves to emphasize the very great need for strengthening the research programs and it becomes obvious that further makeshift adjustments in already inadequate and outmoded facilities would be economically wasteful and scientifically inefficient.

Accordingly, in the summer of 1955 the Bureau initiated planning for a major relocation program. During 1957, a 550-acre site for the new laboratories was acquired. The new site is located at the Gaithersburg interchange of new U.S. Route 240, just 20 miles from the center of Washington.

This site provides the type of location which the Bureau believes is necessary for its new facilities, but it is close enough to the present location to avoid a serious dislocation for most of the Bureau's personnel.

Mr. MILLER. How big an acreage do you have out there?

Mr. CHRISTELLER. 550 acres.

Mr. MILLER. That is at Gaithersburg?

Mr. CHRISTELLER. Yes, we have 68 acres in Washington. The 550 acres were selected from the standpoint of adequate dispersal as to some of the things we have to keep separate from each other and also we hope to give us some protection from encroachment as other facilities are built up.

Mr. MILLER. Those 68 acres are very valuable land if you wanted to turn them into residential property. They have a very high acreage value, perhaps more than offset some of the costs of moving.

Mr. CHRISTELLER. That is right. We would, upon completion of the new facilities, turn the property over to the General Services Administration. There may be one or two specialized buildings that we would feel for a time at least, we would retain. Other than that, we would turn them over to the General Services Administration and they would determine the proper use.

I am sure some of the buildings could continue to be used by the Government, but there is also property there that could be well used in other ways.

Mr. MILLER. It would bring a very handsome revenue to the Government.

Mr. CHRISTELLER. I am sure it would.

The CHAIRMAN. Mr. Christeller, may I interrupt you to make a statement at this point?

Counsel has just informed me that Under Secretary Charles Quarles died last night. He was found dead this morning at 7:15.

Go ahead, please.

Mr. CHRISTELLER. Following up the acquisition of the site, during fiscal year 1959 the Bureau received an appropriation of $3 million to undertake detailed design and engineering for the new facilities. The architectural firm of Voorhees, Walker, Smith, Smith & Haines, which has considerable experience in the design of modern research laboratories, has been retained by the General Services Administration to design the new facilities.

Mr. MILLER. At this point may I ask this question: Are you authorized to do this construction work yourself or do you have to go through the General Services Administration?

Mr. CHRISTELLER. We rely on the General Services Administration in this respect.

The architects and Bureau officials have been making an intensive study of the Bureau's needs and have visited a number of modern industrial laboratories to discuss with the key personnel of those laboratories their experience with research facilities.

The facilities which are now being designed as a result of those studies have as their primary objective the provision of modern laboratories commensurate with the Bureau's responsibilities to the scientific and industrial community. The general character of the facilities and many design details are based on the nature of modern research activities and the experience of the Bureau and the other research organizations with whom we have been discussing this matter.

The major buildings are to be constructed on a modular basis and will use movable partitions. We hope that we will have the flexibility and adaptability of space arrangement which will provide a maximum of utility, efficiency, and operating economy, and will provide the type of facilities which can best meet the needs of a dynamic modern research program.

The proposed facility would consolidate the presently widely scattered component parts of the Bureau's programs into the smallest practicable number of buildings. They will not only permit the initial assignment of space on the basis of close program relationships, but also will facilitate the subsequent reassignment of space as program relationships change.

We find this very important. Similarly the electrical and mechanical facilities, and provision of the movable partitions, will permit appropriate change to meet changing program requirements and we are providing for wing-type structures which will permit the most economic expansion when needed in the future. Our present estimate for the replacement of the existing Bureau facilities with the minimum expansion that is deemed necessary for Bureau programs 5 years hence is estimated to cost approximately $88 million.

In addition to the replacement of existing facilities, the Bureau has identified a number of program areas requiring major new facilities. For example, a high-intensity electronic accelerator is urgently required to provide critically needed radiation standards and measurement techniques, to provide standards of measurement and data for Government installations and industrial facilities which are beginning to use radiation as a processing or analytical tool, to enhance the Bureau's studies in basic research in physics, and to augment the collection of data on the properties of materials.

The proposed linear accelerator would produce electron beams with energies greater than 40 million electron volts and power output greater than 40 kilowatts. This would provide electron beam power from several hundred thousand to a million times the power presently available from equipment at the Bureau. It will therefore extend the capability of the Bureau's high-energy radiation group into whole new research areas.

A second major requirement for which the need has become critical in recent years relates to the Bureau's large capacity force standards.

Since 1927 the Bureau has provided a calibration for force measurement devices. These are devices used for such varied purposes as weighing the contents of tanks and bins, measuring the thrust forces of jet and rocket engines, and serving as load-sensitive devices in the automatic control of machinery.

A deadweight machine is the best device that has thus far been developed for calibration of force-measuring devices. It minimizes extraneous factors by applying directly to the force an accurately known load. Such direct calibrations can only be made, however, for devices below the deadweight limit of the machine. Larger devices must be calibrated only by means of previously calibrated smaller devices and there is a significant loss in accuracy when this indirect method is used.

The Bureau's present deadweight testing machine has a maximum capacity of 111,000 pounds. The large-scale rocket and missile research and development effort that is associated with the ICBM and space vehicle programs has focused attention on the inadequacies in the Bureau's ability to calibrate these devices.

At the present time there is a large demand for calibration of devices of 200,000- to 300,000-pound capacity and there has been a continuing growth in the demand for calibration of even larger capacity devices, some going as high as 3 million-pound capacity.

Mr. MILLER. Are there any such facilities now?

Mr. CHRISTELLER. There are no such facilities in the country for the direct calibration and particularly there are none for calibration in terms of the national standards which are the responsibility of the National Bureau of Standards.

The calibration of these larger devices which we are being requested to provide right now can only be performed at a significant loss of accuracy and this means also a considerable delay in the provision of the service. The delay and the loss of accuracy is creating serious problems for many Government installations, Government contractors, and industrial organizations. To meet the very critical need that has come up in this area, the Bureau is proposing to include in the Gaithersburg facilities a 300,000 pound capacity deadweight test-

ing machine, and a 1 million pound capacity deadweight testing machine.

Mr. MILLER. May I ask—I don't know whether you are familiar with this, but if we had such machines now, would they be very helpful in the present problem of companies in developing some of these engines?

Mr. CHRISTELLER. I think there is no question but that they would be helpful. Dr. McPherson will be speaking in a moment about some of the visits that he has made to other installations of the Government and of Government contractors where the needs for these things have come up. There is no question in our minds that just the testing program for new rocket engines would be significantly advanced and we presume that the cost would be reduced if we were able to provide better service to them in this respect.

Another new facility for which the need has grown steadily over the postwar years is a nuclear research reactor. Without this modern research tool, the Bureau cannot properly cope with its existing scientific and technical problems. This tool would provide new techniques for studying the fundamental properties of matter and would enable us to enter into the provision of high intensity neutron flux standards which we are unable to provide at the present time.

I think Dr. Schoonover will attempt to decide some of the need for this facility and we are including this in the planning of our new facilities at Gaithersburg.

In addition, studies are underway to determine the need for standards and measuring work in the fields of ultrahigh temperature and ultrahigh pressure. It is very likely that new research facilities will be required for these programs.

Now, some of these involve long-range planning so that at the present time I can only say that we think these new program facilities will be on the order of $20 to $25 million in cost in addition to the cost of replacing existing facilities.

Mr. MILLER. Isn't there a Government facility in AEC or is it the new CIA that is located out in that general area?

Mr. CHRISTELLER. Atomic Energy Commission headquarters are now at Germantown, which is 2 miles farther out than the Bureau's facility.

Mr. MILLER. I see. Thank you.

The CHAIRMAN. What testing facilities do they have out there?

Mr. CHRISTELLER. I don't believe the Atomic Energy Commission has any facilities of that nature. That is the headquarters for them.

The CHAIRMAN. Do you do testing for the Atomic Energy Commission?

Mr. CHRISTELLER. We do a great deal of testing for them. In many of the areas I have been discussing they, among others, have been urging us to increase our activities to assist them and their contractors.

I believe this concludes my summary of the budgetary and administrative aspects of the National Bureau of Standards. I should be happy to answer any other questions concerning this either now or after Drs. McPherson, Schoonover, and Birnbaum have made their presentations.

(The tables referred to are as follows:)

TABLE I.—*Summary of total National Bureau of Standards program*

[In thousands of dollars]

Source of support	1958		1959		1960	
	Man-years	Obligation	Man-years	Obligation	Man-years	Obligation
Technical program:						
Federal sources:						
National Bureau of Standards appropriation	1,062.0	$9,723.5	1,247.9	$12,590.0	1,564.9	$17,500.0
Other agency funds	1,526.5	16,432.6	1,448.8	16,518.0	1,329.6	14,906.0
Calibration fees	49.9	424.7	104.8	1,010.0	122.2	1,248.0
Standard sample sales		12.7		15.0		20.0
Subtotal, Federal sources	2,638.4	26,593.5	2,801.5	30,133.0	3,016.7	33,674.0
Non-Federal sources:						
Calibration fees	62.8	534.6	58.1	560.0	63.4	650.0
Gifts	20.2	168.4	14.3	139.0	2.9	32.0
Standard sample sales		165.8		206.0		272.0
Subtotal, non-Federal	83.0	868.8	72.4	905.0	66.3	954.0
Total, technical program	2,712.4	27,462.3	2,873.9	31,038.0	3,083.0	34,628.0
Nontechnical program:						
Plant and facilities	21.6	470.2	44.6	1,076.7	2.4	1,715.0
Construction of facilities		3.1	5.4	2,993.5		340.0
Other agency funds	106.1	1,222.7	99.8	1,123.0	101.9	1,158.0
Production of assets	108.9	[1] [1,121.4]	114.6	[1] [1,040.1]	80.9	[1] [753.2]
Miscellaneous services	106.0	(2)	110.7	(2)	101.8	(2)
Total, nontechnical	342.6	1,696.0	375.1	5,193.2	287.0	3,213.0
Total program	3,064.0	29,158.3	3,249.0	36,231.2	3,370.0	37,841.0

[1] The cost of standard sample production and equipment built by National Bureau of Standards staff is an investment of the Working Capital Fund, recovered through charges to the technical program when standard samples are sold and equipment is depreciated.

[2] Costs of services such as glass blowing, electroplating, optical lens grinding, etc., are charged on a fee basis to the benefiting programs above.

TABLE II.—*Appropriation, "Research and technical services," budget year 1960*

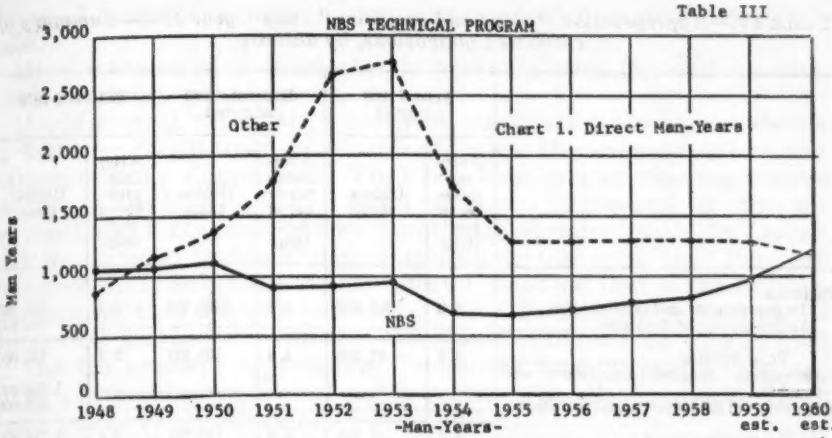
SUMMARY OF ESTIMATED OBLIGATIONS, BY PROGRAM

	Actual 1958 adjusted		Estimate 1959		Estimate 1960	
	Average number of positions	Obligations	Average number of positions	Obligations	Average number of positions	Obligations
1. Physics and electronics:						
Optics and metrology	53.7	$493,296	60.8	$616,000	74.3	$741,000
Heat	62.4	583,734	79.6	878,000	111.3	1,250,000
Atomic and radiation physics	111.3	1,012,861	126.5	1,292,000	156.0	1,622,000
Electricity and electronics	55.9	491,329	69.1	660,000	91.7	873,000
Data processing systems	15.6	147,863	22.2	233,000	41.4	429,000
Radio standards	105.1	948,207	117.2	1,229,000	141.9	1,532,000
Total	404.0	3,677,290	475.4	4,908,000	616.6	6,447,000
2. Chemistry and metallurgy:						
Chemistry	85.2	743,280	96.7	903,000	114.9	1,102,000
Organic and fibrous materials	64.6	572,074	70.4	678,000	82.5	793,000
Metallurgy	38.4	353,372	46.8	453,000	58.0	575,000
Mineral products	59.3	519,101	69.4	667,000	90.0	1,012,000
Total	247.5	2,187,827	283.3	2,701,000	345.4	3,482,000
3. Mechanics and engineering:						
Mechanics	57.8	494,683	72.7	667,000	92.4	877,000
Building technology	47.1	395,278	54.8	502,000	65.8	611,000
Cryogenic engineering	28.0	216,452	32.5	270,000	48.4	433,000
Total	132.9	1,106,413	160.0	1,439,000	206.6	1,921,000
4. Radio propagation:						
Central Radio Propagation Laboratory	2.7	28,151	6.6	58,000	11.3	150,000
Radio propagation physics	168.0	1,758,300	205.1	2,201,000	231.6	2,495,000
Radio propagation engineering	72.9	634,540	74.4	786,000	99.5	1,091,000
Total	243.6	2,420,991	286.1	3,045,000	342.4	3,736,000
5. General services:						
Applied mathematics	21.2	213,510	20.6	238,000	25.2	295,000
Office of Weights and Measures	9.1	84,090	12.1	117,000	13.5	157,000
Office of Basic Instrumentation	.9	8,928	2.7	31,000	3.5	38,000
Technical services	2.8	24,421	7.7	111,000	11.7	149,000
Total	34.0	330,949	43.1	497,000	53.9	639,000
6. Proposed payment to "Working capital fund," National Bureau of Standards						1,275,000
Appropriation or estimate	1,062.0	9,723,470	1,247.9	12,590,000	1,564.9	17,500,000

SUMMARY OF ESTIMATED OBLIGATIONS, BY COST COMPONENT

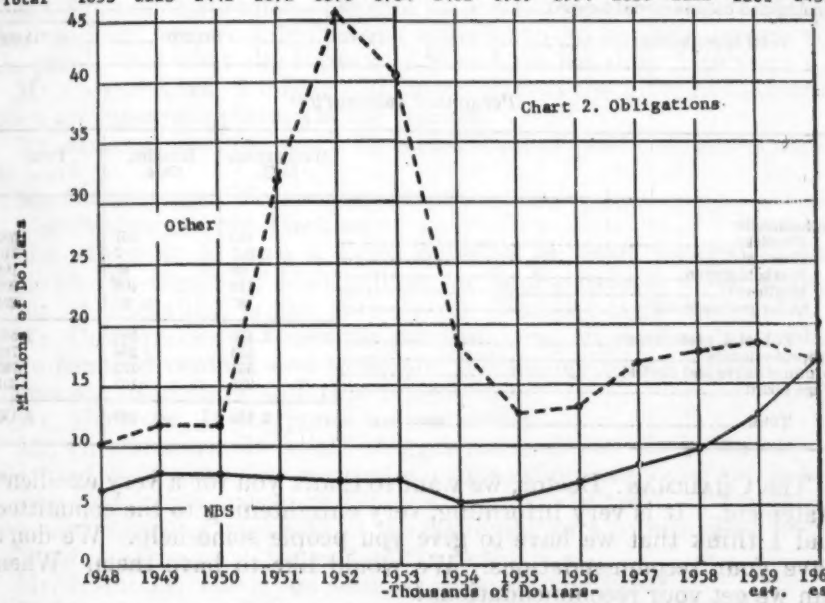
Personal services	821.7	$5,747,894	975.7	$7,423,000	1,232.7	$9,235,000
Other objects		2,044,982		2,787,000		5,358,000
Bureau overhead	240.3	1,930,594	272.2	2,380,000	332.2	2,907,000
Total	1,062.0	9,723,470	1,247.9	12,590,000	1,564.9	17,500,000

Table III



-Man-Years-

	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959 est.	1960 est.
NBS	1004	1075	1071	896	914	947	672	669	710	776	822	976	1233
Other	849	1148	1371	1776	2664	2787	1730	1270	1284	1262	1300	1285	1204
Total	1853	2223	2442	2672	3578	3734	2402	1939	1994	2038	2122	2261	2437



-Thousands of Dollars-

	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959 est.	1960 est.
NBS	6461	7880	7850	7451	7114	7059	5319	5643	6918	8235	9724	12590	17500
Other	10069	11750	11606	31707	45610	40583	18051	12579	13053	16844	17738	18448	17128
Total	16530	19630	19456	39158	52724	47642	23370	18222	19971	25079	27462	31038	34628

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TABLE IV.—*Appropriation, "Plant and facilities," budget year 1960—Summary of estimated obligations, by activity*

	Actual 1958 adjusted		Estimate 1959 adjusted		Estimate 1959	
	Average number of positions	Obligations	Average number of positions	Obligations	Average number of positions	Obligations
Facilities:						
Improvements and construction	4.3	$91,256	4.8	$120,221	2.4	$50,000
Improvement of field sites						100,000
Total facilities	4.3	91,256	4.8	120,221	2.4	150,000
Construction: Boulder Laboratory expansion						1,215,000
Acquisition of field sites: Land purchase						350,000
Total obligations	4.3	91,256	4.8	120,221	2.4	1,715,000
Transferred from Federal Aviation Agency		−98				
Unobligated balance brought forward		−38,688		−20,221		
Unobligated balance carried forward		29,221				
Total appropriation		71,800		100,000		1,715,000

Personnel summary

	Washington, D.C.	Boulder, Colo.	Total
Professionals:			
Physicist	435	157	592
Chemist	307	3	310
Mathematician	68	40	108
Engineers	173	103	276
Other professionals	187	87	274
Subtotal, professionals	1,170	390	1,560
Subprofessionals	523	226	749
Administrative and clerical	551	179	730
Wage board	236	155	391
Total	2,480	950	3,430

The CHAIRMAN. Doctor, we want to thank you for a very excellent statement. It is very informing, very enlightening to the committee and I think that we have to give you people some help. We don't have your recommendations. We would like to have them. When can we get your recommendations?

Mr. CHRISTELLER. We would like to recommend very strongly that you arrange, if possible, an additional discussion with Dr. Astin at a time when both he and representatives of the Department of Commerce could be present to make recommendations to the committee. We are here trying to give you some background which will relate then to the recommendations that he might present to you.

The CHAIRMAN. Well, I would think that we better begin with the Secretary in reference to recommendations, and we will set that down for a hearing at a later date, we will ask the Secretary himself to come down with the recommendations that he may have for your Bureau, because I am deeply impressed, frankly, with the high character and high caliber work that you are turning out. I think that we ought as a committee to show an active interest in your fine work

there. I don't think the public realizes what the Bureau of Standards does.

Mr. CHRISTELLER. I think that is probably true, sir, and we very much appreciate your interest.

Mr. MILLER. I think, Mr. Chairman, our interest can be best shown in assisting the Bureau of Standards when it comes up before the Appropriations Committee. That has been one of the weaknesses because it has had no one to plead its case. It has had to come up by itself and I am certain if we familiarize ourselves with their work and we come to understand and appreciate the work that they are doing we could help them there. May I point out that in the Defense Department they are well publicized every time they turn around. I think that maybe our colleague over on the other side who is part of the Government Operations Committee from time to time has taken a look at the number of public relations people they have. Have you a public relations man on your staff?

Mr. CHRISTELLER. No, sir; we have a scientific information staff whose job is to provide information to the scientific community.

Mr. MILLER. Every time you hit on something new or something that appears new you don't have someone to go out and scream to the press, "See what the Bureau of Standards has done," do you?

Mr. CHRISTELLER. I might add, however, that the press has learned there are interesting things at the Bureau.

Mr. MILLER. But you don't have that kind of public relations man, do you?

Mr. CHRISTELLER. No, sir, not in that context.

The CHAIRMAN. Mr. Hechler.

Mr. HECHLER. I have a brief question on land purchase. On table IV, the figure of $350 million for land purchase, under acquisition of field sites; is this entirely for Gaithersburg?

Mr. CHRISTELLER. I think the problem here, sir, is that the tables have changed context and these are full amounts here rather than thousands of dollars and this is $350,000.

Mr. HECHLER. It staggered me somewhat.

Mr. CHRISTELLER. It would stagger me, too, sir. It is the acquisition of field sites for our radio propagation program which requires sites in a number of different locations in terms of transmission and receiving sites both at the beginning of a transmission path, at a midpoint, and at the end of the path.

Mr. HECHLER. Have you selected those specific sites?

Mr. CHRISTELLER. Yes; we have. In fact, several of them are under lease at the present time. We find significant problems in occupying leased sites because there are statutory limitations on the kinds of things we can do in terms of improvement of the site and we are therefore requesting the funds to purchase five sites. We have a site at Havana, Ill., we have one at Haswell, Colo., one at Gunbarrel Hill, Colo., one at Marshall, Colo., and one at Table Mesa which is right outside Boulder, Colo.

Mr. HECHLER. Thank you.

Mr. MILLER. What are these sites for?

Mr. CHRISTELLER. Radio propagation.

Mr. MILLER. This is the work you do from Cheyenne Mountain?

Mr. CHRISTELLER. Part of the work from Cheyenne Mountain is involved. That is being handled on a lease arrangement. And we

feel the lease arrangement there is satisfactory. But the sites, for instance, out on the plains are related to and are needed for the Cheyenne Mountain work.

The CHAIRMAN. Mr. Christeller, you say there are statutory limitations on your purchases.

Mr. CHRISTELLER. The limitations, sir, exist in terms of the construction on leased property. Quite appropriately we are not permitted to make improvements to someone else's property and where we need to make improvements and where we feel that there is a reasonable assurance of a continuing long-term need for a particular site at some point, we feel the need then to purchase that site rather than continue it under lease.

The CHAIRMAN. Well, do you have statutory authority to make purchases?

Mr. CHRISTELLER. We have statutory authority now. It was passed by the last session of Congress to permit us to purchase field sites, assuming these are specifically covered in our appropriation act for a particular year.

The CHAIRMAN. So you have statutory authorization to purchase certain field sites?

Mr. CHRISTELLER. That is right.

The CHAIRMAN. How many sites?

Mr. CHRISTELLER. We are now proposing to purchase five. In addition we are compelled to purchase one to replace the present radio field site at Sterling, Va., which happens to be adjacent to, in fact it is partly on the property of, the Chantilly Airport. We will have to move our radio receiver site from the airport location when the airport goes into operation, so we will also at some point be purchasing land for replacement of that site.

The CHAIRMAN. This is really six sites.

Mr. CHRISTELLER. It is subject to the provision in appropriation acts of funds. There is no limitation on the dollar amount or the field sites. These are subject to a specific appropriation provision at the time we request the funds.

The CHAIRMAN. Mr. Riehlman.

Mr. RIEHLMAN. This isn't tied in with the present discussion, Mr. Chairman, but I just wondered, if you could tell us very briefly as to what degree NASA is looking to the Bureau of Standards for assistance.

Mr. CHRISTELLER. We have always worked closely with NASA's predecessor, the National Advisory Committee for Aeronautics, and have conducted a number of programs for them over the years. We are continuing some of those programs and we are working also on some new programs related to the space responsibilities of NASA. They rely on our Central Radio Propagation Laboratory with respect to some of the work going on in the fields of ionosphere research. They look to our Cryogenic Engineering Laboratory for assistance in problems of low temperature properties of materials, which relates to the use of liquid fuels. They look to a number of our groups in our Washington laboratories for specific assistance on technical problems and, of course, all of their work ultimately comes back to a need for more precise standards and methods of measurement, so we are working very closely with them in many ways.

Mr. RIEHLMAN. Now, is the Bureau of Standards paid for the work that it is doing for NASA?

Mr. CHRISTELLER. Any work we do for them is on a transfer of funds; we do provide consultative services financed by our own funds, but specific research jobs are financed by other agencies.

Mr. RIEHLMAN. And you do have specific research jobs with NASA at the present time.

Mr. CHRISTELLER. That is right. I might add that our relationship is very close because the Deputy Director of NASA is an alumnus of the Bureau.

Mr. RIEHLMAN. That is all I have, Mr. Chairman.

Mr. MILLER. Mr. Chairman, I used the term Cheyenne Mountain a minute ago. I think maybe one of these gentlemen might explain to you the work they are doing in Colorado, because they can do that better than I can. It is most interesting.

Mr. CHRISTELLER. I think some of the Cheyenne work may have been completed. We did work at Cheyenne Mountain for a period in connection with the responsibilities of the Air Navigation Development Board. We were able to use a transmission site high up on the mountain to transmit radio signals which, with receivers out on the plains, could therefore simulate air-to-ground and ground-to-air communication. This was one of the jobs that we did at that site. This permitted us also to extend our radio propagation research with respect to line-of-sight transmissions.

Mr. MILLER. And to get a lot of the bugs out as to radio contact heretofore made, particularly with respect to the navigation of airplanes and to allow the conduct of air navigation to be much safer as a result of the work done there.

Mr. CHRISTELLER. That is right, sir, and this has been with respect to the navigation and control facilities that are now being put into the various airports throughout the country in the Federal airways system.

The CHAIRMAN. While you are on that general subject, tell me this: What are you doing in reference to space communications? You referred to that yesterday or the day before.

Mr. CHRISTELLER. The space communications work relates to our central responsibility for radio propagation research. Dr. Astin mentioned yesterday that one of the additional items of interest that we have in this area is that the earth satellites provide new techniques for studying some of the things that we have been studying only from the ground. We, for instance, have been able to use some of the satellites as a means of sounding the ionosphere from above rather than from below. In terms of space communications we are working with the people in the Department of Defense and the people in NASA in terms of their problems and their interest in these programs.

The CHAIRMAN. Well, do you have any particular project on it?

Mr. CHRISTELLER. I think that one might say that all of our work in the study of the nature of the ionosphere and the effects of the ionosphere on radio communication are ultimately associated with the space communications problems and in this respect then a great segment of our work in a radio propagation program is related to this. I would be happy to have the people who are doing this work provide

a statement for you of specifically how they relate to the space communication program.

The CHAIRMAN. We would like very much to have it.

Mr. CHRISTELLER. Fine.

(The information requested is as follows:)

RELATIONSHIP OF PRESENT CRPL PROGRAM TO SPACE COMMUNICATIONS AND SPACE RESEARCH

Three of the present CRPL activities are directly related to plans for present or future satellites or space vehicles. One of these is the observation of radio signals received from satellite transmitters. Distortions observed in such signals give both direct information on radio communications possibilities, and also information on the medium through which the signals pass. A second program involves a study of the feasibility of mounting a radar sounder in a satellite. Information coming from such a sounder would be telemetered to the ground and provide data on ionization densities in the very high atmosphere. The third direct program involves participation by the IGY World Warning Agency—run by CRPL—in worldwide communications involving the launching and orbit determinations of satellites.

Three other programs involve studies related to the guidance and tracking of satellites and space vehicles. When radio signals travel from a space vehicle to the earth or vice versa, they are refracted or bent by the various layers of the ionosphere. This bending limits the accuracy with which the space vehicle can be tracked or guided. A study of tropospheric refraction and phase stability is providing such information at microwave frequencies. Another program is analyzing regular radio sounder data and preparing special charts to permit the estimation of refractions associated with space vehicle signals. The third program is directly observing the refraction and scintillations of radio noise signals from radio stars which are produced in traversing the atmosphere.

Several more CRPL programs are providing basic physical information concerning the outer fringes of the atmosphere and interplanetary space. A new technique of direct electronic backscatter radar observations is providing information on amounts of ionization and on temperature of the outer fringes of the atmosphere. Observations of whistlers—naturally occurring audiofrequency electromagnetic signals—utilize signals which go as much as 10,000 miles out into space and return, giving information on ionization densities in those regions. Studies of naturally occurring VLF emissions are providing information on the interrelation between atomic particles in space and the earth's magnetic field. Observations of radio noise emitted by the planet Jupiter have provided information on the characteristics of planets other than the Earth. In studying the night airglow, information has been obtained on the zodiacal light which is related to the density of dust particles in interplanetary space. A program on infrared spectroscopy of the high atmosphere is aimed at deducing the concentration of molecular components in that region. And finally, a study of the number of meteors arriving in the high atmosphere provides some information related to meteoric densities in space.

In addition to the direct research programs, the CRPL is providing advisory services in a number of areas of the space program. Personnel from CRPL hold positions as adviser to the U.S. delegation to the United Nations Ad Hoc Committee on Peaceful Uses of Outer Space, member of the Space Science Board of the National Academy of Sciences, member of NASA Working Group on Satellite Ionospheric Beacons, member of the Working Group on Space Surveillance, Special Committee on Space Technology of NASA, member of Special Committee on Satellites, Office of the Secretary of Defense, member of the Commission on Cosmic-Terrestrial Relationships of the American Geophysical Union, vice chairman of the U.S. National Committee for IGY, and member of the (International) Special Committee for the IGY. Several members of CRPL participate in the working groups under the Space Science Board and the panels of the U.S. National Committee for IGY.

The CHAIRMAN. Any further questions? If not, we certainly thank you, Mr. Christeller, for a very informative statement.

Mr. CHRISTELLER. Thank you, sir.

The CHAIRMAN. Now, we have Dr. A. T. McPherson, Associate Director for Engineering. Dr. McPherson will discuss extension and improvement of calibration services.

STATEMENT OF DR. A. T. McPHERSON, ASSOCIATE DIRECTOR FOR ENGINEERING, NATIONAL BUREAU OF STANDARDS

Dr. McPHERSON. Mr. Chairman, since I am responsible for the service activities of the Bureau, I want to speak about the way in which the national standards maintained by the Bureau reach those who need to use them in science and industry and commerce and trade. As Dr. Astin told you yesterday the demand for standards has been mounting very rapidly, with the current advances in science and technology in the space age. This need is nowhere more acute than in the ballistic missiles program, so I shall refer to that program to illustrate some of the services that the Bureau is currently rendering and to show some of the urgent standardization problems that confront us. The Bureau uses about five principal means of translating the national standards into everyday use. One of the first and earliest means used was to provide the States with standards which they use in the enforcement of uniform weights and measures. In the United States, as you know, it is the States and local jurisdictions that are responsible for the correct use of measures of weight, length, volume, and so on. The Bureau has no statutory responsibility for enforcing weights and measures and it seeks none, but the Bureau does have definite responsibility assigned to it by its basic legislation for cooperating with the States in developing uniform weights and measures laws and it exercises this cooperation largely through a National Conference which is made up of State and local weights and measures officials.

Through the Conference the Bureau assists the States in developing model laws and regulations and also specifications and tolerances for weighing and measuring equipment. The uniformity among the different States now is such that manufacturers and distributors working across State lines seldom encounter any difficulty on account of varying regulations from one State to the other.

Shortly before and after the Civil War the Federal Government provided the States and Territories with physical standards of weights and measures. Since that time some of the States have still been using their original standards, sending them in periodically for check. Other States have bought new ones and many States have not been provided with them. Fortunately the new State of Alaska was recently provided with a complete and up-to-date set of weights and measures to be the basic set for weights and measures enforcement in Alaska.

The CHAIRMAN. Do you have a list of States that are complete in that respect and a list of those that are not?

Mr. McPHERSON. We have been making a survey, sir, and I will provide such a list for the record.

The CHAIRMAN. Fine.

(The information requested is as follows:)

According to files at the National Bureau of Standards the only State which never received any standards from the Federal Government was Oklahoma.

The following States did not receive metric standards: Alabama, District of Columbia, Florida, Georgia, Montana, Nevada, Utah. Records are not clear as to Arizona, Idaho, and South Dakota.

The following States did not receive sets of agricultural standards for the use of land-grant colleges: Arizona, District of Columbia, Idaho, Montana, New Jersey, New Mexico, North Dakota, South Dakota, Utah, Washington, and Wyoming.

The sets furnished some States have been lost by fire or through other circumstances.

Because of widely different circumstances in the different States it is not possible at this time to furnish a list of States that now possess State standards adequate to meet their current needs.

Dr. McPherson. We are in the process of developing plans for providing the States with new and up-to-date standards. In the standards of weight our Metallurgy Division has started at the beginning and has developed a special stainless steel alloy. We have made a prototype 1-pound measure here from a special alloy which will have greater permanence, will be much more useful as a standard than the brass weights which were formerly used.

The Chairman. You mean that is a standard for 1 pound?

Dr. McPherson. This, sir, is a standard for 1 pound. You may see it, if you like.

The Chairman. All right, would you pass it around. What is the advantage of that?

Dr. McPherson. The advantage is that this is a one-piece weight which can be adjusted by electropolishing to very precise weight. It will not tarnish or change weight in service. It is so hard that we expect very little wear in service.

The Chairman. Well, now, will that be identical with the British pound?

Dr. McPherson. That will be the new pound. We have a new international pound which is fixed by agreement among the six English-speaking countries whose pounds previously varied by small amounts.

The Chairman. Will this be the international pound?

Dr. McPherson. This, sir, will be the international pound.

Mr. Miller. How much did they vary by?

Dr. McPherson. I don't have the exact figure. It was a matter of a few parts per million.

Mr. Miller. For all practical purposes insignificant. If you bought a pound of sugar you weren't going to be cheated very much.

Dr. McPherson. No, but for scientific purposes there is a difference.

Mr. Miller. That is another story.

The Chairman. Now, that will be the basic pound, this particular one will be the basic one.

Dr. McPherson. We plan to make pounds, and 50-pound and thousand-pound weights which will be distributed to all of the States along with measures of length and measures of volume.

The Chairman. Now, what is that pound made of?

Dr. McPherson. This is made of a special stainless steel alloy.

The Chairman. But what is the alloy?

Dr. McPHERSON. I don't have the composition, it is a nickel, iron, chromium alloy.

Mr. MILLER. You notice the doctor didn't put his fingers on it because he doesn't want to corrode it and change its weight. You will have to throw that one away.

Dr. McPHERSON. This is for demonstration purposes. If it were being used as a standard, it, of course, would not be touched with human hands.

The CHAIRMAN. That is not the identical one but one for demonstration purposes.

Dr. McPHERSON. This is an accurately adjusted one and we would plan to make 50 of these for the 50 States.

The CHAIRMAN. I wish the record would show that the chairman didn't touch it either.

Mr. King.

Mr. KING. Isn't it true, Doctor, that because of the fact that earth is not completely spherical actually you have a little weight differential depending upon the place on the globe at which you are making the test and if that be true how do you adjust that fact to your absolute weight?

Dr. McPHERSON. This is a standard of mass, which is different technically from a standard of weight. Weight is the force of gravity on a given mass. With a spring balance the weight would be different at different places on the earth's surface, but when two different masses are compared by means of a beam balance any variations in the force of gravity from one place on the earth's surface to another, would affect the object being weighed and counterpoise the same so the effect would cancel out. It is said in our most precise weighing we can get a difference, by putting two weights one on top of the other than by putting one beside the other on the pan because the one on top is a little farther removed from the center of the earth. I can't vouch for the accuracy of that, but we do take things like that into account.

One of the other methods of making standards available is for people using the various weighing and measuring instruments to send them to the Bureau for comparison with the national standards. Now, that was done pretty generally before World War I. In World War I there were large numbers of gages required for checking the dimensions of guns and ammunition, and in order to calibrate and certify those gages, it was necessary for the Bureau to get up 4 laboratories in different cities with a total personnel of 168 people who were doing nothing but standardizing the dimensional gages that were required. That situation, of course, could not be continued so that soon after World War I the different users of dimensional gages set up their own standards, laboratories and the standardization of gages has now been decentralized to a point at which 9 to 10 people at the Bureau provide all of the standards that are needed for the country. That is, we calibrate specially made gage blocks and specially made gages for screw threads and for other items that have to be measured accurately, and they are used by other laboratories in turn to calibrate other gages which in turn are used to calibrate the working gages. The magnitude of the problem is illustrated by the fact that the Navy Department alone has 1 to 3 million gages. So it is

necessary to have not one but a series of steps of standards laboratories, in order to keep the gages in the shop in correct adjustment.

Mr. MILLER. Doctor, years ago when the automobile industry was coming into its own, the Society of Automotive Engineers had operated a series of standards for threads and instruments. Have those become pretty much standard now for industry generally through the country?

In other words, you used to talk about an SAE thread, and so on.

Dr. MCPHERSON. These standards for threads are covered as far as the Government is concerned by Bureau handbook H–28 which is used by all of the Government agencies. These standards are close to or identical with the SAE and other standards in industry. Standardization of screw threads is coordinated through the American Standards Association.

Mr. MILLER. So when we build airplanes I presume that we use the same thread standards on those that were used when the automobile was originally coming in to get this common standardization through the Government, is that correct?

Dr. MCPHERSON. We generally use about three types of standard threads in mechanical equipment, a coarse thread No. 1; a finer thread, No. 2, which is commonly used in automobiles and gives a better fit; and then a No. 3 which gives the maximum strength for airplanes and other critical uses where weight must be saved. Our major channels now for maintaining standards is through the instrumentality of these other standards laboratories.

The CHAIRMAN. What do you do in reference to gasoline which is of interest to all of us?

Dr. MCPHERSON. The octane rating, sir, is maintained by a committee of the American Society for Testing Materials. They set up a large stock of reference fuels for test purposes. The Bureau determines the properties of these reference fuels which are then distributed through that ASTM committee to people who have the problem of checking the fuel produced by the different refiners.

The CHAIRMAN. Well, what about the gallon, do you standardize that?

Dr. MCPHERSON. The gallon is provided through standards which we furnish to the States, and they check their replica standards and ultimately each filling station pump is checked by a local inspector, usually with a 5-gallon measure which is related through two or three different steps to the standard measures at the National Bureau of Standards.

The CHAIRMAN. No effort has been made to standardize the Canadian and the American gallon.

Dr. MCPHERSON. They are too far apart for standardization, sir. We have standardized the Canadian, the American, and the British inch, as I said, but they were close together. The gallons are so different that there is no possibility of confusion.

The CHAIRMAN. One more question on that subject.

Dr. MCPHERSON. Yes, sir.

The CHAIRMAN. Do you standardize, not the octane, but the viscosity of crude oil?

Dr. MCPHERSON. The Bureau does distribute standard samples of oil of accurately measured viscosity, and those standard samples are

used by refiners and others. We are considering getting out of that business because a company in cooperation with a committee of the American Society for Testing Materials is interested in setting up and maintaining those standards. Whenever it is possible for us to do so, we turn over the simpler standardizing operations to other groups or agencies. They still come back to us for a check on the basic standards, but if they can serve as distributors we are happy to have them do so.

The CHAIRMAN. Mr. Wolf.

Mr. WOLF. I am just wondering if any attempt has ever been made to standardize internationally. Is there a committee at work through the United Nations or any other agency to have an international standard on most everything?

Dr. MCPHERSON. Since the Treaty of the Meter in 1875 the United States has participated in the work of the International Bureau of Weights and Measures in matters pertaining to the basic standards of mass length, and time. In addition, the Bureau participates in a number of international standardizing organizations. Dr. Birnbaum will speak more about these organizations, in which many people from both Government and industry in the United States participate. There is an International Union of Pure & Applied Chemistry, an International Union of Pure & Applied Physics, and many other organizations of that kind. Trade and science are worldwide now and international standardization is a must.

Mr. WOLF. This was the thing that was brought home to me traveling in Europe a couple of years ago. We got into these Iron Curtain countries, traveling with an agricultural group, trying to establish the butterfat content, for example, the production of a single cow, or the production of a number of bushels of a piece of ground. First we had a mistake in the size of the unit that they were talking about, it was hectares instead of acres, then the unit by which they measured the production of the hectares was different. It was quite a problem trying to establish comparative productions and things of this kind. Even their mileage was different. They measure in terms of a different system. I am glad to hear there is some work being done in this.

Dr. MCPHERSON. The Bureau is cooperating actively in the development of a new wavelength standard of length. We expect that in 1960 the 11th General Conference on Weights and Measures will adopt the wavelength of an orange line from the Krypton spectrum as the basic international standard of length. This will replace the prototype platinum-iridium meter bar because the meter bar is no longer sufficiently accurate for many purposes. The meter is defined as the length between two fiducial marks on the bar. Those marks necessarily have a finite width and there is an uncertainty in determining the meter more precisely than to 1 part in 10 million, but with the wavelength standard any laboratory can, with the proper equipment, maintain its own standard of length perhaps to a part in 100 million or perhaps even to 1 part in a billion at the limit.

Mr. WOLF. That is getting it down pretty fine.

Dr. MCPHERSON. One of our most accurate standards are the standards of time intervals and frequency which are made available to anyone who wants to use them by broadcasting from station WWV in Beltsville and station WWVH in Hawaii. The signals from these

stations now are probably correct at the source to about a few parts in 10 billion. We hope ultimately to achieve accuracy of a few parts in a thousand billion but corrections must, of course, be made by the users for distortion in transmission. This is an ideal way to make standards available with a minimum amount of work on the part of the Bureau.

Mr. MILLER. How long have you been doing that—broadcasting?

Dr. MCPHERSON. I don't recall. It is probably 20 years, but I can insert that in the record, sir.

Mr. MILLER. Well, that is all right. That is a time signal that is given.

Dr. MCPHERSON. The signals include eastern daylight time, international time and standard frequencies which the different radio stations use to maintain their broadcast frequencies. The broadcasts also include a frequency of 600 cycles by which the power companies accurately control the 60 cycle current and thereby enable electric clocks to keep correct time. We have in addition 440 cycles, A above middle C, which musicians use for purposes of tuning their musical instruments.

The CHAIRMAN. Well, now, the Navy radio station here signals the time all over the world; they get that time from you.

Dr. MCPHERSON. This time is gotten in cooperation with the Naval Observatory. The motion of the earth varies from day to day and year to year. The standard second is fixed by reference to the year 1900.

Mr. MILLER. I was up in Vancouver some years ago and a sightseeing man told us at noon they fired a cannon originating from the time signal sent out in Washington. They are wasting a lot of powder up in Vancouver.

Dr. MCPHERSON. Our responsibility is for the time intervals and for the frequency. The Naval Observatory has responsibility for the time.

The Bureau has many practical means of making standards available for every day use. Just to illustrate this, here are standards of color for kitchen and bathroom fixtures furniture. These enable manufacturers, whether they make porcelainware, wood products, or fabrics, to keep the colors sufficiently close so that there will be no disharmony in color. The Bureau provides about 550 standards for industry in the form of pure materials and analyzed samples of industrial materials. The steel and metals industries use standard samples as a basis for quick tests and analyses. It is much easier to make a comparative analysis than to make an absolute determination. Hence when a sample from an open hearth or blast furnace, for example, must be analyzed in a matter of minutes and the chemist assures himself of the correctness of the analysis by simultaneously analyzing an appropriate standard sample of similar and accurately known composition. The standard samples include a number of pure materials. This sample of benzoic acid, for example, is used as a standard of acidimetry and as a standard heat of combustion. It is used also as a standard melting point sample to calibrate thermometers.

Last fall Major General Howett asked the Bureau to cooperate in setting up an Air Force National Bureau of Standards working group

to go out to the various Air Force contractors in the ballistic missile program and find the present standardization requirements that are not now being met and the need for future standards.

A team of individual scientists who were qualified in particular fields went to eight of the Air Force contractors in the missiles program. They included General Electric, Convair, Douglas, Rocket-Dyne, Aerojet, Martin, A. C. Sparkplug and Sperry-Rand.

This survey showed a general need for increased accuracy at nearly every level and also a need for extending the range in which measurements were made both to high ranges and to low ranges.

Now, Mr. Christeller mentioned briefly our plans for a new facility for measuring large forces. The present capability of the Bureau is perhaps one or two-tenths of a percent in the large forces which must be measured by indirect means. We are planning a facility in which it will be possible to apply a million pounds of deadweight either in tension or compression to any measuring device. That will be a new departure in the design of testing equipment and we will do it in two stages, by building a 300,000-pound machine first and then a million-pound machine. The need for this was brought out very strongly in our survey.

Some of the engineers at Aerojet at Sacramento, Calif., said it would probably save $150 to $200 million in testing costs to be able to make the tests with a very much greater precision than is now possible. With the new equipment we are hoping to calibrate thrust measuring devices to something like five one-thousandths of a percent.

Now, we have worked closely with manufacturers of the force measuring equipment. They have been much concerned about the present inadequacy of the Bureau's facilities and one of the major manufacturers, Baldwin-Lima-Hamilton, undertook a survey in which they went to all of the known users of large force measuring equipment and asked about their needs. The needs were almost universally for greatly increased accuracy and for the measurement of forces at least up to a million pounds.

In the range of pressure measurements, there is need to go from very low pressures to very high pressures and also to measure instantaneous pressures in connection with the transient forces that are obtained in missile and rocket engines.

In the field of low pressures, they want standards which will measure the pressures equivalent to altitudes of 500,000 feet and above, where the atmosphere is nearly as rare as in the best vacuum that can be produced in the laboratory.

This need is urgent and the Bureau has already initiated some work in the field. We are likewise initiating work in the high pressure field which Dr. Schoonover will mention presently. There is need in the low temperature field for measuring liquid oxygen, gasoline, and other fuels with a very high precision at very large rates of flow. In the radio field, our Radio Standards Laboratory at Boulder is confronted with the job of developing national standards for high frequency and microwave measurements at the same time that they are called on to make actual calibrations of instruments. It is a rather confused situation to be called on to make measurements before we are really adequately staffed and equipped for it, but the needs are such that we are doing the best we can.

To forestall a repetition of this problem and meet future needs, we have arranged with the Air Force to go to their advance planning research and development personnel and find out the items of equipment that are being planned for development several years hence so that we can begin planning the standards that will be needed to make the measurements with the precision that the engineers will require, and have those standards ready by the time the new equipment is in production.

The CHAIRMAN. Doctor, I think you have given us an excellent idea of the whole program there. I was thinking we would like to hear from Dr. Schoonover before we adjourned. I don't want to cut you short in any way, but——

Dr. MCPHERSON. I had just reached the end of my remarks, sir.

The CHAIRMAN. You have given us an excellent idea of your problem. What we are going to need really is a recommendation from the Secretary when he comes up.

Dr. MCPHERSON. Yes, sir.

The CHAIRMAN. Now, Dr. Schoonover, do you have a statement?

Dr. SCHOONOVER. No, I don't, sir. I would like to speak from notes.

The CHAIRMAN. Well, we would like to finish with you today if we can and then we will take Dr. Birnbaum later on.

We will have to get to him when the Secretary comes down.

STATEMENT OF DR. IRL C. SCHOONOVER, ASSOCIATE DIRECTOR FOR PLANNING, NATIONAL BUREAU OF STANDARDS

Dr. SCHOONOVER. Well, I would like to present, Mr. Chairman, another area of work which the Bureau has been concerned with throughout its entire history, and this is the area of precise measurements on the properties of material, the accumulation of engineering data and the dissemination of such engineering data.

This is an area in the Bureau's programs which I would like to think of as being sensitive—sensitive in the sense that it must change rapidly with every new breakthrough in science; every new development really affects our work in this field. Materials suitable for industrial exploitation of all new breakthroughs in science are often the real stumbling block to the success in these fields and thus our work in the field of materials must be constantly changing with the new scientific accomplishments.

I would like to cite a few examples of this: One is in the field of very high temperatures. For many, many years, the Bureau has been measuring the mechanical properties, electrical properties, thermal properties, and other properties of a host of materials at temperature ranges from well below zero up to about 1,500° C.

We were really not very much interested above 1,500° C. because there weren't any industrial applications above 1,500° C. and there was little scientific interest above 1,500° C., but all of a sudden we find we have atomic power, we have space flight, space exploitation, high-speed missiles, and so forth, which are requiring materials that must reach temperatures not at 1,500° C., but 2,000°, 3,000°, 5,000°, and on up. All of a sudden we find that we are catapulted into a brand-new field of science where we must extend our efforts to making measurements in an area we have never tackled before.

We know that it is not possible from actual expérience to extrapolate our knowledge from the low temperature into the high temperature field because in many cases we have had evidence of complete reversal of properties; things that one would predict that would happen at the higher temperatures don't happen at all, and the properties may be completely reversed from what one expects.

Well, the Bureau last year, through the efforts of the 85th Congress, and through their support, did undertake to expand its efforts materially in this field. We were granted roughly $1,200,000 for the purpose of extending our work in this area. During the past year I think we have made rather significant progress in the ability to attain high temperatures. We now have a high current arc which will permit us to get to temperatures of about 15,000° C. Prior to this we couldn't approach this at all. We are also able to measure temperatures to a higher degree than we were in the past, and although we are still far behind the needs in this field, we are in a position to begin to meet these needs through the current programs.

In this program we have roughly 40 different projects. I have prepared a review of the past year's work. At the time it was prepared, it was for the House Appropriations Committee. I have only one copy, but I would be pleased to pass it out if you would like to see in general what this review is. Otherwise I can have other copies made.

The CHAIRMAN. We can set it forth in the record.

(The review referred to is as follows:)

REPORT ON HIGH TEMPERATURE RESEARCH, BY A. V. ASTIN, DIRECTOR, NATIONAL BUREAU OF STANDARDS

The funds made available and specifically designated by the 85th Congress for support of work in the field of very high temperature have enabled the Bureau to make substantial gains in this area during the past year. Our ability to fulfill our responsibilities in furthering our national technological competence in attaining, maintaining, and measuring very high temperatures has been materially improved. Marked progress has also been made in devising and developing equipment for measuring the properties of materials at very high temperatures. New work in the field of ultra high temperatures, where matter exists only in a gaseous form, has been initiated. A complete listing of all the projects supported by this appropriation is appended to this report. Some of the specific accomplishments in these areas are as follows:

I. PRODUCTION AND MEASUREMENT OF VERY HIGH TEMPERATURES

(a) *Design and construction of high current arc*

A major program was initiated to extend our capabilities in the production and measurement of temperatures of much higher level than heretofore possible. A high current arc was constructed and installed as a source of high temperatures, and at the present time temperatures of 15,000° C. have been achieved and measured approximately. The difficulties of working at such temperatures are formidable. Sufficiently accurate methods for temperature measurements in this region must be established. This requires a very thorough study of all the properties of very hot gases, and it will be several years before really adequate standards are available.

(b) *Improvement and extension of the range of pyrometer calibrations*

The temperature range over which optical pyrometers can be calibrated was extended significantly. By the use of zirconia and carbon arcs as sources of high temperatures, the range of possible calibrations was extended from 2,400° to 3,800° C. This is an important accomplishment, but the range needs to be extended to very much higher temperatures.

A very careful recalibration of NBS standard pyrometers was completed. As a consequence, a significant improvement in the NBS temperature scale between 1,063° and 2,400° C. was achieved. This permits more accurate calibrations to be carried out for the development of high temperature devices, such as missile nose cones and rocket motors. A further improvement in this area is being accomplished through the use of photoelectric devices. An experimental model has been constructed, which indicates that it is possible to build an instrument with greatly improved accuracy, as much as tenfold over that of current methods.

(c) Measurement of temperature under nonideal conditions

Temperature measurement is relatively easy when all conditions can be controlled, as is the case in the laboratory. In the field, however, special problems arise from the fact that systems such as jet or rocket motors are not used under laboratory conditions or control. An active program to establish standards of measurement of high temperatures under nonideal conditions was initiated during the year. At present, equipment is being constructed to study the use of spectroscopic methods for this purpose.

(d) Temperatures of streams of hot gases

Modifications and improvements have been made on the apparatus available for this work, in which the immediate objective is the determination of a reference table for iridium versus iridium plus 60 percent rhodium thermocouples up to 2,100° C. A complete determination of the EMF-temperature relationship of one thermocouple has been made, and it is expected that values on at least two more thermocouples will be obtained within the next 2 months. The results obtained to date are being used widely by engineers engaged in research, development, and manufacture of jet and rocket engines.

II. PROPERTIES AND BEHAVIOR OF MATERIALS AT HIGH TEMPERATURES

(a) Viscosity of liquids and gases

A high temperature viscosimeter for liquids is being constructed, which will permit the Bureau to extend the temperature range for such measurements by 1,000° C. or more. The major parts of this apparatus have been constructed and assembled, along with the auxiliary equipment necessary to obtain, maintain, and measure viscosity of molten materials. A new series of high temperature viscosity standards will be developed, using this instrument. Development of the high temperature viscosimeter for investigating the viscosity of gases was also undertaken. Currently, equipment has been constructed and operated successfully at over 1,000° C., and it appears that it will be possible to extend the operating temperature to 2,000° C. and above without any foreseeable difficulty.

(b) Thermodynamic properties of inorganic solids

A microbalance sensitive to weight changes of the order of one microgram and capable of operating at temperatures up to 2,000° C. was constructed and is being used to study the rate of solid-gas reactions occurring at high temperatures in light element compounds, e.g., aluminum, beryllium, and magnesium oxides. Such data are needed for the evaluation of possible solid-fuel propellants for rockets.

(c) Elastic constants of inorganic solids

Existing equipment for investigating the mechanical properties of solids was modified and improved to permit data to be obtained on the elastic constants of inorganic solids at temperatures up to 2,000° C. Work is currently in progress on some of the more refractory oxide crystals.

(d) Heat capacity measurements

Our ability to measure heat capacity has been limited to measurements from near absolute zero to approximately 1,500° C. Work has been initiated to extend this range up to temperatures of at least 2,500° C. Some of the equipment has been constructed, and design studies for the laboratory are completed.

(e) Solar furnace

Work was completed on accessory equipment for a small solar furnace. Temperatures as high as 3,400° C. have been attained on this instrument. Data were obtained on the melting point of some of the more refractory oxides

(aluminum and titanium oxides). This equipment has also proven to be most valuable in studying the reactions occurring between gases and solids at very high temperatures.

(f) Thermal expansion of crystalline solids

The high temperature furnace previously developed at NBS, and capable of being operated up to 1,500° C., for studying polymorphism and thermal expansion of crystalline solids by X-ray diffraction techniques, is being rebuilt to enable such measurements to be made at very much higher temperatures.

(g) Phase relations of systems at high temperature

Basic data on equilibrium phase changes occurring in both high temperature inorganic nonmetallic and metallic systems have been obtained. Tentative phase diagrams on a number of systems involving trivalent rare-earth oxides have been prepared and published; also similar diagrams for a number of the refractory metals and their alloys were completed and published.

III. ULTRA HIGH TEMPERATURE RESEARCH

An understanding of the properties and behavior of highly ionized or very "hot gases" is of the utmost importance to the Bureau, because of the need for developing methods for measuring very high temperatures and the need to attain a competence capable of conducting investigations on the chemistry and physics of "hot gases." Such work is most important in support of many of the programs of our Boulder Laboratory in their current invesigation of the ionosphere, and will be even more important in support of many of the major problems which must be undertaken by the new Space Agency.

Work was initiated to devise experimental methods for simulating plasmas of ionized gas on a laboratory scale, in order that the fundamental characteristics of such gases could be better studied and understood. In support of this work, new efforts in the field of magneto-hydrodynamics, spectroscopy, and high temperature physics were undertaken as a part of the overall high temperature program.

IV. FUTURE NEEDS AND SUMMARY

Although the Bureau is in a much more favorable position to undertake high temperature investigations than it has been in previous years, our efforts still fall short of the needs in many areas. For example, our work at ultra high temperatures is in its infancy, partially because of the need for securing additional highly competent staff to direct work in this area and, more so, because our present facilities and equipment are inadequate to attain the temperatures needed. The electrical power requirements for the development of extremely high temperature sources are very large, and are presently the subject of a detailed study. Furthermore, a recent comprehensive study of our needs for an adequate program to study "hot gases" indicated that substantial funds would be required to fill in the apparent gaps in our existing program. Additional personnel and new equipment will be required if we are to meet the current needs for our Boulder programs and if we are to attain a competence in the field of chemistry and physics of "hot gases" necessary to the development of methods for measuring ultra high temperatures. Some of the funds required for both staff and equipment are included in our current budget request.

Although significant advances have been made in devising and developing highly specialized equipment and techniques for investigating the properties of materials at high temperatures, the level of the effort that can be directed to obtaining data is much too low to meet the immediate needs. Additional support is required to make the most efficient use of the equipment that has been or is in the process of being developed for work in this field.

Furthermore, it has not been possible with currently available funds to include in our present program some of the supporting efforts that will be required for successful prosecution of our high-temperature research efforts. For example, the need for highly purified and/or highly characterized substances will become increasingly more important because of the necessity of studying the effect that traces of impurities have on the behavior of materials at high temperature. Some experimental data are available which indicate that impurities even in trace amounts exert a profound effect on the properties of materials at high temperatures.

High-temperature programs supported from Bureau funds

Project	*Title*
0328	High-temperature gas thermometry.
0340	High-temperature physics.
0342	High-temperature chemical processes.
0343	Production and measurement of very high temperatures.
0303	Heat measurements.
0324	Intermolecular forces.
0327	Molecular structure and spectroscopy.
0304	High-pressure, high-temperature thermodynamics.
0306	Cooperative phenomena.
0322	Oxidation of hydrocarbons.
0642	Viscosities of gases at high temperatures.
0636	Dynamic properties of materials at high temperatures.
0741	High-temperature, heat-resistant fluorine polymers.
0802	Properties of metals at high temperatures.
0811	Studies of the structure of metals at high temperatures.
0834	Deformation of titanium, titanium alloys, and other metals.
0837	Constitutional diagram for 16 percent Cr–2 percent Ni stainless steel.
0840	Alloy theory.
0839	Diffusion in solid state.
0904	High-temperature phase equilibrium of inorganic nonmetallic systems.
0942	Study of structural defects in refractory metallic oxides by dynamic measurements at high temperatures.
0949	High-temperature viscosity and surface tension.
0945	Chemical reactions of inorganic materials at high temperature.
0908	High-temperature bonding of ceramic metals.
0907	Polymorphic transformations at high temperatures.
0305	High-temperature heat capacities.
0307	Research on automatic bridge for temperature measurements.
0412	Radiometric standards.
0520	Purification and preparation of inorganic substances for high-temperature research.
0902	Physical properties of refractory materials for high temperature.
1062	Thermal conductivity of materials at temperatures at 2000° C.
0301	High-temperature resistance thermometry.
0302	Development of temperature-measuring instruments.
0341	Measurement of high temperatures by optical pyrometry.
0644	Measurement of temperatures of streams of hot gas.
0614	Development of techniques for load, strain, and deformation measurements at high temperatures.
0635	Calibration standards for vibration pickups.
0402	Atomic energy levels.

Dr. SCHOONOVER. Well, this is one example of the dynamic nature of the Bureau's efforts in this field of precise measurements. Another example of this, I think, could be given in the field of high pressure, the high pressure work that Dr. McPherson alluded to.

Industry today is attempting to develop new and rather exotic materials by exposing these materials to terrifically high pressures and temperatures. One good example of this is the production of synthetic diamonds that the General Electric Co. has succeeded in doing by high pressures and by high temperatures.

Another is the development of a material called "Coesite," which is ordinary sand compressed to a very high temperature and pressure. This has some rather remarkable properties. There is a trend in industrial development to go to these terrifically high temperatures and high pressures with the possibility of collapsing the atomic structures in some form and having them remain collapsed and stable and thus create new materials.

The Bureau will be called upon here to devise methods for maintaining very high pressures and measuring these pressures and de-

veloping safety practices for the use of high pressures which do not currently exist and also measuring the behavior of materials at these high pressures.

At the same time that this is going on, we are going to the other end of the pressure scale as a result of space exploration. We are now concerned with what happens to an alloy, for example, if it is placed in outer space in a vacuum. Will it evaporate, will it lose weight rapidly, will it become brittle because of the diffusion of certain elements out of the alloy in this vacuum, and this means that a whole host of new programs must be undertaken to understand the behavior of materials now, not at high pressures, and high temperatures, but in the absence of pressures or under high vacuums. This is another indication of the dynamic nature of our program and how it must change from time to time to meet the needs of modern new breakthroughs in science and new technological developments.

There is another area that I would like to talk to in this field and that is the need for some rather basic approaches to the studies of materials. All of the engineering profession and the scientific profession concerned with devising and obtaining materials for use in these new developments are beginning to become concerned with the crash programs that we have to undertake in order to find out whether we have some material, for instance, that will be suitable for a nose cone on a rocket or whether we have a material that will be suitable for outer space exploration.

We don't know these things and we have large crash programs to try to find them. There is a feeling now among the materials engineers in this country that we should go back and do some rather fundamental studies on real pure substances. If we would take, for example, iron and purify it so there are no impurities or at least the minimum amount of impurities and place this in some simple structural form and then investigate its properties thoroughly in this condition and then begin to add to this iron impurities, imperfections, and changes in its structure and study the behavior of this material or the effect that these changes had upon it, we would then understand what causes changes in properties and what things bring about desirable changes and what things bring about undesirable changes.

Now, if we do this on a rather large scale, we ought to reach the point that we could begin to build into iron specific properties to meet specific needs rather than to use these trial-and-error methods or undertake these crash programs to find a suitable material by what I would call Edisonian methods.

This is a field that the Bureau must help in. Our part in this would be largely one of trying to supply very high purity materials for science in general, for our own staff and for science outside, to supply highly purified materials which can then be treated in the fashion that I have discussed such as adding these contaminants or adding changes to them. This is more or less a logical extension of the Bureau's efforts in the field of standard samples, probably on a little more high level plane in that we would have to employ a large portion of our staff or the facilities of our staff to produce these materials and to characterize materials. By characterize, I mean to determine whether they are in this crystalline form or that crystalline form, whether they have this impurity or that impurity, whether they are—well, a complete picture of the material as it is. This is a field that we are currently ex-

ploring and that we have requested assistance from Congress on and in which we would hope to establish what I call a pure substance bank or a crystal bank as it has sometimes been called.

It would be a bank of materials which would be available for the solid state physicists, the metallurgists, the chemists, the engineers, to do basic studies of the type that I have just described in the field.

The CHAIRMAN. Thank you very much, Doctor.

Dr. SCHOONOVER. You are welcome.

Mr. MILLER. Have the steel companies ever tried to undertake some of these studies with respect to removing all of the impurities from iron?

Dr. SCHOONOVER. Yes, they are trying to do this but this is a real difficult job. This is not something that one can do with an ordinary program. One has to bring to bear upon this a whole complex of facilities and capabilities and competences that are not always available in any one place. I think we have this at the Bureau to a high degree.

The CHAIRMAN. Well, that is the fundamental principle behind the alloy, is it not, mixing impurities and noting the changes and you are just going to extend that same principle so as to do it systematically, a systematic study of the whole element, like iron.

Dr. SCHOONOVER. Yes, so we can get away from this crash program, so we can intelligently design the things we will need for the future.

The CHAIRMAN. Do you have a similar program in reference to petroleum?

Dr. SCHOONOVER. There has been at the Bureau in the past, and still is to some extent, a program preparing pure hydrocarbons. These are for the purpose of carrying out studies in the organic field of the type that I am talking about in the inorganic field.

The CHAIRMAN. Then you have a program too, don't you, in reference to coal which would cover carbons?

Dr. SCHOONOVER. I think you have reference to the Bureau of Mines. I don't believe we have that.

The CHAIRMAN. You don't have that?

Dr. SCHOONOVER. No, not for coal.

The CHAIRMAN. Any questions?

If not, gentlemen, we have one more witness this morning, Dr. H. Birnbaum, Assistant Director. I would think, however, it is 12 straight up and we have to have one more session in order to hear the Secretary with his recommendations and if there is no objection I would think it would be preferable to hear Dr. Birnbaum at that time rather than now, so if there is no further business here this morning, we will recess until Monday morning at 10 o'clock.

By the way, I mentioned to the press that the hearing coming up Monday is really a hearing to bring us down to date on the progress of Russian science, especially space science. Incidentally, it is going to take in the so-called hoax story, but I think it is better to characterize it as a general investigation of the progress of Russian science and it is my thought that the witnesses ought to be sworn in for this particular hearing.

So we will recess until Monday morning at 10 o'clock.

(Whereupon, at 12:01 p.m., the committee recessed, to reconvene at 10 a.m., Monday, May 11, 1959.)

BRIEFING BY NATIONAL BUREAU OF STANDARDS

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
Washington, D.C., Thursday, May 21, 1959.

The committee met, pursuant to recess, at 10 a.m., Hon. Overton Brooks (chairman of the committee) presiding.

The CHAIRMAN. The committee will please come to order.

We are a little slow getting started because we have had a hard day, or hard days I should say, before the House, but we are honored this morning to have the Assistant Secretary of Commerce, Mr. Carl F. Oechsle, to appear before us.

Now the Secretary has direct charge of the Bureau of Standards and this committee has jurisdiction over the Bureau. We have had witnesses from the Bureau give a rundown on its activities. What we asked the Secretary to do was to come here and advise us as to the overall picture. A great many statements were given to the committee about facilities at the Bureau of Standards being outmoded, outdated, or poorly arranged, and about new tracts of land being purchased. So the committee has agreed that after we hear you, Mr. Secretary, and any overall picture that you may bring to us perhaps at a later date, we are going to refer the matter to the Miller subcommittee. We want to be thoroughly informed as to the fine work that the Bureau of Standards is doing and the needs of it with the idea that this committee can be of assistance to the Bureau in meeting its obligations to the public as I know they want to meet them.

With that preface, Mr. Secretary, we are very happy to have your prepared statement.

STATEMENT OF CARL F. OECHSLE, ASSISTANT SECRETARY OF COMMERCE FOR DOMESTIC AFFAIRS, DEPARTMENT OF COMMERCE

Secretary OECHSLE. Thank you, Mr. Chairman.

Mr. Chairman and members of this committee, I am honored to share in these initial hearings of this committee which has been designated by the Congress to consider the substantive affairs of the National Bureau of Standards. I want to take this occasion to welcome your interest in the Bureau and to assure you of our intention and purpose to cooperate with you and keep you thoroughly informed of the activities of the Bureau as they materialize.

We will not impose on this newly formed relationship by bringing to your attention and requesting your assistance in matters which are merely gleams in the eyes of our people, or items where the necessary approval has not been obtained in the executive branch. Such actions

would be wasteful of your time and premature if taken before the proposals have become part of the legislative or fiscal program of the President. We believe that within the executive branch it is our responsibility to urge acceptance of our plans. Our success or failure in discharge of this responsibility is a measure of our competence in administering the laws establishing and governing the Bureau.

However, when substantive legislative items are coordinated within the executive branch, when programs are carried out by the Bureau, and when appropriations for our activities are approved, we will inform this committee comprehensively and most earnestly look to the committee for assistance in their function.

Certain study and planning activities should be brought to your attention. About a year ago, the Director of the Bureau outlined to the Secretary of Commerce a number of major needs of the Bureau of Standards. Some of these were implemented by the last Congress, others are included in the budget request for the Bureau for 1960 which has been described by Mr. Christeller. Still others are under current consideration. Some of the remaining recommendations are being evaluated in terms of their impact on other bureaus of the Department as well as on other agencies of the Government. In addition, the Secretary has requested the National Academy of Sciences to undertake a careful review of the scientific activities of the Department of Commerce in relation to national needs and to make recommendations in the national interest. The report from the special committee established by the National Academy is expected in about 2 months. An important aspect of this report will deal with the National Bureau of Standards. The report will become a subject for study and recommendations to this committee and to the Congress.

The importance to the Department of Commerce of the interest of a substantive committee such as this is enormous, and we welcome suggestions and recommendations from you concerning the role of our scientific and technical bureaus such as the Bureau of Standards.

By this sort of cooperation we believe that the utmost in our relationship with the committee will be achieved, and it is our expectation that our relationship will serve as a model to other agencies and committees.

Dr. Astin, the Director of the Bureau; Dr. McPherson, associate director for engineering; and Dr. Schoonover, associate director for planning, have appeared earlier in these hearings to acquaint you in detail with certain aspects of the work of the Bureau. Our budget officer, Mr. Christeller, has given you in detail our appropriation picture now in effect and as presented for fiscal 1960.

At this time I would like to have Dr. R. D. Huntoon, Deputy Director, acquaint you with our programs on time standards and then have Doctors Astin, Huntoon, Wichers, and Birnbaum speak in reply to specific questions which have been raised earlier in these hearings by members of this committee. Dr. Astin will talk on the status of the English and metric units; Dr. Wichers on international activities of the Bureau; and Dr. Birnbaum on informational activities of the Bureau.

Now that is the end of the official statement as far as I am concerned; but for the benefit of the committee, in November of 1958 the Reader's Digest had a great interest in the National Bureau of Standards and

they published an article in their November issue, and I have some copies of it here that I would like to make available to the members of your committee. It is really a very interesting one and gives you a good boiled-down idea of what the National Bureau of Standards does and what their responsibilities are.

The CHAIRMAN. Fine. Mr. Secretary, we thank you for a very fine cooperative statement and I want to say on behalf of the committee we welcome you here for the first time before this committee. As your statement implies, we are anxious to work with you and to help the Bureau of Standards in every possible legislative way.

Secretary OECHSLE. I think you will find, Mr. Chairman, that that will be a two-way street.

The CHAIRMAN. Thank you, sir. Now you suggest that Dr. Huntoon, Deputy Director, would like to make a statement at this point.

Secretary OECHSLE. Yes, sir.

Dr. ASTIN. I might preface this statement, Mr. Chairman, by the observation that 2 weeks ago Mr. Fulton raised a question about the status of time standards particularly with respect to space exploration, so I have asked Dr. Huntoon to make some general observations on the overall status of our time standards and perhaps this will cover the question raised by Mr. Fulton.

STATEMENT OF DR. R. D. HUNTOON, DEPUTY DIRECTOR, NATIONAL BUREAU OF STANDARDS

Dr. HUNTOON. Mr. Chairman, members of the committee, the precise measurement of time is a most fascinating undertaking. Fortunately time is one of the physical quantities which today we can measure with about as great precision as any and yet in spite of this it still is in the position of needing even greater precision of measurement. Perhaps I should begin this morning by making it clear we are concerned with the scientific aspects of time measurement and not some of the practical considerations like the setting of daylight saving time, which is not one of our responsibilities.

Le me begin by saying that time is rather difficult to define but for the present discussion we will be in accord with modern definitions if we say "time is what the heavenly bodies pace out as they go through their stately motions."

As in measuring any physical quantity, we have to agree on a unit. I am sure you are all well versed in this particular unit, the second; have used it throughout your lives. Having agreed upon the unit one must have a standard by which one can make measurements in terms of the unit.

Now since ancient times our standard of time has been the rotating earth as one of these heavenly bodies going through its ordained motions. We define the second to be one eighty-six-thousand-four-hundreths part of a mean solar day. This has served us as a fine standard for many years but in modern times it has turned out that this rotating earth as a standard of time has certain deficiencies.

The speed of rotation of the earth varies seasonally. The earth wobbles on its axis slightly and for some unforeseen and unknown reasons the period of rotation of the earth as checked against the stars occasionally abruptly changes by a small but a significant amount

in terms of modern measurement. So we must seek for a better standard. Within the last few years, actually in 1955, the International Astronomical Union decided to adopt an ephemeris time scale which is based on the earth making its trip around the sun as opposed to the earth spinning on its axis. There is reason to believe that this is a much more stable system of reference.

In 1956 the International Congress of Weights and Measures also adopted this ephemeris time scale.

Now again from year to year this time standard would vary but in order to make it precise and reproducible it was decided that the time for the trip of the earth around the sun in 1900 would be the time standard and we would define the second as 1 divided by 31,556,925.9747, of the time required for the trip around the sun in 1900.

Mr. ANFUSO. Mr. Chairman.

The CHAIRMAN. Mr. Anfuso.

Mr. ANFUSO. Could you not have given us that figure without reading it?

Dr. HUNTOON. No, sir. The number was 1 divided by 31,556,925.9747. That is the definition of the ephemeris second, that fraction of the time it took the earth to make its trip around the sun in 1900.

Mr. FULTON. What is the other second on a solar day?

Dr. HUNTOON. Solar second, I believe.

Well, now having these definitions, it then becomes necessary to get clocks which keep time in terms of these definitions in order to get a time scale which is tied to this rotation or orbiting of the earth around the sun. You will remember in ancient times to split a day down into pieces sundials were used, but in relatively recent times it emerged that repetitive systems, that is vibrating systems, afforded a much better basis for subdividing the long measured day into the second and parts of a second. You will remember from your reading of the invention of the pendulum of the balance wheel in your watch, each of these is a repetitive system by which you can count and by counting subdivide the day or year into the requisite parts.

As scientific progress has gone on, other vibrating systems have come into use. The tuning fork, the vibrating quartz bar which times our broadcasting stations and is a timing standard of the day; organ pipes, and of most recent vintage atomic vibrations or nuclear transitions about which I will have a little bit more to say later.

The essential point here is by using a system which vibrates regularly one can count the vibrations and use this to subdivide the large unit into smaller units. Today it is possible by means of these vibrating quartz bars to get a clock and to get it in step with the ephemeris time definition with a precision of something like 20 parts in 10^{10}, 2 parts in a billion.

Now perhaps it would be helpful to pause here just a moment to aid your understanding by reading you a few numbers. A part in a million would represent a clock which keeps time to 1 second in 12 days. A part in a hundred million is a clock which will keep time to 1 second in 3 years. At this level of 1 second in 3 years we begin to observe the deficiencies in the rotation of the earth—1 part in a billion, or 1 second in 30 years, is about the degree to which we can adjust modern clocks to the new ephemeris time.

As we have learned to use these faster and faster vibrating systems we find it is possible to compare them as timekeepers and find they have greater precision than our ability to compare them with ephemeris time will permit us to evaluate. So we now have clocks which can keep time, one with respect to the other, with greater accuracy than it is possible to ascertain the length of this ephemeris year, and scientists are urging that we not only have this ephemeris time which is time determined by the motion of the heavenly bodies but for certain scientific work we need an atomic time, time controlled or clocks controlled by the vibrations of atomic system, for we need greater precision than this 1 part in 10^9.

This is the ideal conceptual framework for our time measurement. Now let me say a few words about how it gets translated to your own watch from there.

We maintain at the National Bureau of Standards a set of vibrating quartz bars. These time the vibrations of our radio station WWV and these vibrations are broadcast throughout the country. They are guaranteed to be accurate to one part in a hundred million; that is, to 1 second in 3 years. These are monitored by the U.S. Naval Observatory and checked against star transits daily, weather permitting. By watching this clock against the star transits it is possible to check the broadcast time against ephemeris time or as in years past, against solar time. When our time pulses that are put out by WWV deviate by 20 one-thousandths of a second from the correct astronomical time then our clock is reset by 20 one-thousandths of a second and this is published in the appropriate scientific journals. At the same time the frequencies which we broadcast are maintained constant with respect to an atomic system, a cesium clock which is good to about 1 part in 10 to the tenth, that is 1 second in 3 centuries. Periodically we publish corrections to the frequencies as broadcast to bring them to an accuracy of one part in a billion. Those broadcast frequencies can then be used by power stations, by the people who make and regulate clocks and watches, to establish our practical time system and it is used to set the whole time framework for our Nation.

The CHAIRMAN. May I ask you a question or two?

Dr. HUNTOON. Yes, sir.

The CHAIRMAN. Where are those experiments being undertaken at this time?

Dr. HUNTOON. Which experiments, sir?

The CHAIRMAN. In reference to more accuracy in time. Actually it is hardly an experiment when you get down to 1 in a billion or 1 in 10 billion, but where are you handling those timepieces?

Dr. HUNTOON. We are doing it in two places. We are doing it in our Boulder Laboratories in Boulder, Colo., where the actual time standard is maintained and the control of our frequencies is maintained, and in our Washington laboratories.

The CHAIRMAN. Well, now I have been told that the vibrations are such out there on Connecticut Avenue that that property is not now suitable for the Bureau of Standards and that was one reason we asked the Assistant Secretary to come here. I am wondering since he is here, and we do not have the opportunity of having him here every day, if he would like to say anything on that point.

Dr. HUNTOON. May I say a word on it first?

The CHAIRMAN. If you will.

Dr. HUNTOON. The vibrations referred to of Connecticut Avenue upset some of the experiments there but they would not affect our time standards. The vibrations of Connecticut Avenue are so slow that the instruments making these time measurements do not respond to that. There are many other standards in which we are involved that do need freedom from vibration but it so happens that this particular one does not.

The CHAIRMAN. You are being forced then to move some of your standards and some of your experiments elsewhere on account of the vibrations there?

Dr. HUNTOON. Yes, sir.

Secretary OECHSLE. That is probably one of the reasons we went to Boulder, Colo.

Dr. ASTIN. No, as Dr. Huntoon mentioned, this is not a factor in the time measurement.

Dr. HUNTOON. I think having led you this far in the story of time I ought to say just a few words as to why one is so interested in this tremendous precision.

As we move into this space navigation, the problems of navigation become ever more difficult and require ever greater precision. Perhaps I can lead you to an understanding of the situation by using as an example navigation on the earth. Roughly when you are at the Equator the earth is moving about 1,500 feet a second. You arrive at your position partly by keeping a clock or a chronometer which tells you the time of day in terms of a clock from where you left and then you watch the solar bodies, the celestial bodies, to find the time where you are. A comparison of these times tells you your position. If this clock does not keep time, if it loses a second a day, your apparent deduced position is shifting a matter of a thousand feet a day.

If you want to know your position to a foot a day you need a clock which can keep time to a millisecond a day. If you are off for 30 days, then your position is off by some 30 feet, if you cannot check back against the reference clock. So you can see if you want to get navigational precision of the order of a few feet you need clocks that can keep time to the order of a millisecond per day, this is parts in 10^8, or a hundred million, which is the time I mentioned earlier of something like a second in 3 years.

Now it is very convenient and most useful, as you know, to use electromagnetic radiations for measuring distances today. They move at the rate of a thousand feet in a millionth of a second. So, if we want to use clocks to time pulses, to tell where we are with respect to other positions and use electromagnetic radiations, we need clocks that will keep time to within a millionth of a second, if we are to know our relative position to a thousand feet and if we want to go away and be gone a day we need a clock that can keep time to within a millionth of a second in a day, and now we are talking parts in a thousand billion which is a factor of 10^{100}, better than we have today. So we have much to shoot for yet.

One could go into other classified areas for the need for great time precision, but I gather we do not want to get involved in classified matters. That essentially is the story.

The CHAIRMAN. Mr. Fulton.

Mr. FULTON. Obviously when you came up with your 1/86,400, you simply took the number of seconds times 3,600 times 24 and came up with that figure so you really came up with what a day would be, leaving leap year out of it, did you not?

Dr. HUNTOON. When they go to the ephemeris second——

Mr. FULTON. On the solar second, the 24-hour day has no relation to the year at all, has it?

Dr. HUNTOON. That is correct; it was one daily rotation of the earth.

Mr. FULTON. The next question is this: We are talking of time on earth and this committee is interested in space. That brings up the question how do you relate the earth time you are speaking of with astronomical time? For example, at the M–31 distance, the time it takes light to come from M–31 as an astronomical unit. How do you fit that in? I have been interested, you know from my questions previously, how we would ever get the special measurement and the time measurement on earth related to outer space measurements. Nobody has ever done that. Do we put it at the first point of Aries, maybe December 31, 1999, so we then get two times one to the fourth in order to get a point that is easy to work with?

Dr. HUNTOON. Certainly some point must be agreed on by common accord.

Mr. FULTON. I was thinking of taking a point in time, such as December 31, 1999, which gives you the year 2000, which gives you an easy 2 times 10 to the third to work with.

Dr. HUNTOON. Yes.

Mr. FULTON. So mathematically it is easy to handle. Then should we compute the first point of Aries at that particular year, 1999, we would have some way to get out into astronomical space and time. There has never been a link-up between the earth time and earth measurements with astronomical and at this particular point we certainly need it and I wish you would make a recommendation to me so I can put in a resolution to link the two kinds of time and space.

Dr. HUNTOON. This is not something I would be in a position to do today.

Mr. FULTON. Well, I would like your recommendations so we can put in the kind of resolution that would be a link-up so we can pick the point on the earth from which we make all of the measurements, so we link them to the astronomical measurements and also that we pick the point in time, so there can be correlation and we can then do it at a time that it is easy mathematically to come up with something.

Dr. HUNTOON. I think this is something we should discuss and I want to get a clear understanding of what you want and see if we can provide for you what you wish to have.

Mr. FULTON. I would like the basis for such a resolution. Does it sound practical to you others?

Dr. ASTIN. I am not sure that I fully understand just what it is you want but we would be glad to discuss this with you later and see then if we could initiate a study and make recommendations.

Mr. FULTON. I want to relate earth time, earth space measurements to astronomical time on space measurements and pick a point on the earth at a suitable time that you can easily mathematically come up with something like 2 times 10 to the third.

Dr. ASTIN. Yes, I think that is practicable and we will explore the problem and report back.

The CHAIRMAN. I want to come back to the original idea here of the meeting this morning. I have read and reread the Secretary's statement. Is it possible to give us any long-term objectives or aims of the Bureau of Standards or any long-term needs of the Bureau of Standards?

I notice you state in your statement that at this time recommendations would be not in order because the approvals have to be made by the executive branch and by the President, but is it possible for you to give us an idea of any of the long-term objectives which you know about or any of the long-term needs which you know some day are going to have to be met, that do not necessarily have to constitute a program of the executive branch?

Secretary OECHSLE. Well, I think I discussed that with you last night, Mr. Chairman, and stated that we were having a complete study made that would be available in about 60 days.

The CHAIRMAN. Well, shortly before you made a purchase of a tract of property you had some reason for buying it?

Secretary OECHSLE. That is true.

The CHAIRMAN. What is the reason for buying it?

Secretary OECHSLE. I think Dr. Astin can answer that.

The CHAIRMAN. You have some reason for having the place out in Colorado. I would like the subcommittee to see the facilities that you have at Colorado and I think the committee would like the subcommittee to visit your Connecticut parent facilities and also to see the location that you have already acquired in Maryland.

Secretary OECHSLE. I think that is fine. We would be very happy to set up a date with the subcommittee and take them through the Bureau of Standards and also the new location and also go out to Boulder and look that site over. I think Dr. Astin can arrange that and would be very happy to.

The CHAIRMAN. Tell us the reason for having those facilities and why did you need to require something there?

Dr. ASTIN. Well, I can cover both points I think very briefly.

The decision to relocate the National Bureau of Standards, or the main part of the National Bureau of Standards at Gaithersburg was based upon the evaluation that the growth responsibilities and importance of the National Bureau of Standards required facilities greatly superior to those that we now have and that it was impractical to provide those needed facilities and the growing facilities which we need on our Connecticut Avenue site.

The CHAIRMAN. What are the growing facilities that you need?

Dr. ASTIN. In the first place there is extensive modernization of our present laboratory facilities. There is need to develop facilities in the area of high temperature measurements and high pressure measurements. There is need to provide better facilities for studying standards in measurement problems with respect to nuclear and atomic radiations and the facilities specifically for these three types of activities, that is, atomic and nuclear radiation studies, high temperature studies, and high pressure studies would be difficult to locate on our present site. The need for new facilities plus the need for extensive renovation of our present facilities were the factors leading to the decision to relocate.

The CHAIRMAN. Now why would you locate in Colorado? What kind of location do you have out there?

Dr. ASTIN. The location in Colorado was selected for our radio work. This includes the Central Radio Propagation Laboratory which was established by interdepartmental agreement and by appropriation authorization of the Congress about 1947, and with establishment of the Central Radio Propagation Laboratory there was immediately begun a program of planning a facility for it.

The Congress specifically suggested at that time that that facility not be located in Washington. So we made a rather extensive study of possible new sites for it, and after looking at a number of locations, the Boulder site was selected, and I can tell you briefly what the factors were.

There was need to locate the Boulder Laboratory in a place that would be relatively free from manmade electrical noise and at the same time not too remote from a major transportation center. Boulder meets the one requirement. It is only 25 miles distant from Denver and so it meets that requirement.

There was also need for location near various types of terrain in order to study radio propagation effects over various types of terrain. Boulder offered an ideal opportunity in this connection because one has the mountains to the west of us and the plains to the east of us, so there is a wide diversity of terrain for that purpose.

In addition, there was need to locate the facility near an important university. We consider the continual improvement of our staff through study, contact with university people, an important element for the maintenance of quality, so selection in a university town was another factor. These are briefly the factors which led to the location at Boulder, Colo.

The CHAIRMAN. What do you mean by "radio propagation"?

Dr. ASTIN. Radio propagation refers to the mechanism of getting a radio signal from a transmitter to a receiver. Long-range radio communication depends upon reflection of radio waves from the electrical reflecting part of the atmosphere which we call the ionosphere, and a large part of the work of the Central Radio Propagation Laboratory deals with the study of the characteristics of the ionosphere and their effect on radio propagation.

In addition we study the characteristics of the earth as they affect the shorter range and to some extent even very long-range radio propagation properties and, in addition, we study the properties of the lower atmosphere, which we call the troposphere, as they affect so-called line of sight radio communication.

Now all of these characteristics of the atmosphere which affect the properties of the signal which one gets at the receiver from the source we call radio propagation.

The CHAIRMAN. So your place at Boulder, and I am just asking for information, is a center for the propagation of radio?

Dr. ASTIN. That is correct.

The CHAIRMAN. And that would be in line with experiments for earth as well as experiments out in deep space, for instance trying to reflect a radio wave off the moon or off satellites.

Dr. ASTIN. Yes.

The CHAIRMAN. That is the point I wanted to get to the committee.

Dr. ASTIN. Yes, these activities are in our area of interest. As a matter of fact, we demonstrated in our Central Radio Propagation Laboratory some years ago the feasibility of communication bouncing waves off the moon and transmitting an intelligible teletype signal between two distant points by reflection from the moon.

The CHAIRMAN. Mr. Moeller.

Mr. MOELLER. Mr. Chairman, I was going to ask an additional question. Then it is not alone the interference of the vibrations on Connecticut Avenue that prompts this move?

Dr. ASTIN. Oh, no.

Mr. MOELLER. That is a small reason?

Dr. ASTIN. I would say that is a relatively minor item, but I might make this general observation: The present site on Connecticut Avenue was selected in 1901 and the Bureau occupied its first buildings there in 1903. At that time that site was essentially a rural site and it was selected deliberately for that reason. We do need considerable space around them and although the site was ideal in 1903, the city has now grown up around us and so in seeking a more adequate site for modernization of our facilities we used essentially the same criteria that were used in 1901.

Mr. FULTON. The question comes up, why was the site in West Virginia overlooked that would be just about as good as out in Colorado?

Dr. ASTIN. I do not recall specifically what sites were looked at. It was about 1950, as I recall, when the study was made, but I know that a half dozen sites that roughly——

Mr. FULTON. These characteristics you have enumerated were looked at and the selection team made a recommendation to the then Director of the Bureau, Dr. Condon, that the Boulder site most adequately fulfilled all of the requirements.

The CHAIRMAN. Well, you bought it and you have it now.

Dr. ASTIN. Yes.

The CHAIRMAN. The question in my mind is are you going to plan on further expansion of that site?

Dr. ASTIN. At Boulder?

The CHAIRMAN. Yes.

Dr. ASTIN. Well, we do plan further expansion and actually one element of planned expansion of the Boulder site is included in our 1960 budget. The laboratory there consists of a central spine with wings attached to it. The initial plan for that laboratory called for six wings. We were authorized to build only four at the time and actually that laboratory was completed in 1954. A couple of years ago the Congress authorized an additional wing for the building which was completed last year, and our 1960 budget would provide for a sixth wing on the building, so expansion for that site is also planned.

Mr. FULTON. Would you yield there?

The CHAIRMAN. Mr. Fulton.

Mr. FULTON. My point is really this: I would like to see some consideration taken of these areas of chronic unemployment and depression in the planning of your installations, and secondly, that we do not get them too much concentrated at one particular point, both for the purposes of U.S. security as well as the safety of your installation, and secondly so that in these scientific developments each State

of the 49 States of the country will have an adequate share of the distribution of these installations.

Under those circumstances I would like you to look in each case to see whether you are to expand at the particular location or whether with equal scientific gain and convenience you could have these laboratories and installations located, not particularly in my State of Pennsylvania but in other States. I could see where you might get a gain through having various universities who would add units onto their present equipment and have better scientific training and use of your facilities in various parts of the country.

I wish you would take those factors into consideration and especially when I brought up the State of West Virginia, the research by the German scientists and the Japanese scientists in the thirties and the forties established an electronic pole in West Virginia, so there is quite a situation as far as anything that is going to be concerned with things of this type and should not be overlooked.

Secondly, West Virginia, Dr. Hechler will confirm, is quite a depressed area and it would be a help not only to their economy but to their universities to have these installations added as extra parts of their own laboratories. That does not mean that we should divide up where it is not feasible to do so, but I would like to see in your particular agency the division among many universities and many research centers of your functions so that we do get a broad pattern of distribution throughout the country.

Dr. ASTIN. Well, we would like to make greater use of university resources in helping us carry out our functions and it is one of the long-range objectives that we have.

Mr. FULTON. What steps are you taking to do that now?

Dr. ASTIN. Well, at the present time we have enlisted Harvard University in one important phase of the radio propagation activity. We also make important use of Stanford in connection with the radio propagation.

Mr. FULTON. Having gone to Harvard I am not biased, but it always seems to me that the same universities, the same locations, are being used and expanded.

Now the problem comes how do we really and seriously get an adequate distribution of this scientific pattern through this country, leaving all humor aside? How do we get it so we get an overall coverage with many participants of universities, not against any State, and not for any State?

Mr. MILLER. Will the gentleman yield. Does perfection not beget perfection. Harvard has a reputation, it has had a lot of money, a lot of fine things have been done there, does that not attract these other things coming in here?

Mr. FULTON. Yes, but it is a question of policy as to how we direct it and maybe it is an educational method here that can be used.

Mr. MILLER. If my friend will yield, is the function of the Bureau of Standards, or to get away from that, the function of any governmental research agency, to get at the truth and to get the best results for the Government or is it the function of that agency to take care of the economy of some section of the country?

Now to me it is very plain. You are going to put these places where you have got the best brains and where you can get the best

results. If we have got to build up the economy of the country let us go after it another way, but let us not burden a research agency with the necessity of serving either the selfish political ends of some Member who wants to get one of these installations in his district or to say we are going to put it in this place or that place because this is an area that needs employment.

Mr. FULTON. The gentleman has a real point and it is a difference in philosophy. I am an exponent of one philosophy and I think you have adequately stated the other philosophy.

Mr. MILLER. My philosophy is get the job done in the best way we can.

The CHAIRMAN. May I interrupt with this thought? The Bureau of Standards has not indicated any program of acquiring new sites. I am merely trying to find out the "why" of the present sites. The subcommittee has been appointed. If the Bureau of Standards has a program of acquiring new sites, I hope the subcommittee will look into it, Mr. Miller, all of your subcommittee, and in that connection make recommendations to the full committee.

Mr. MILLER. And we will invite my good friend who says he has an opposing philosophy to come in and sit and advise.

The CHAIRMAN. Mr. Anfuso.

Mr. ANFUSO. Mr. Chairman.

In the Reader's Digest reprint, entitled "Headquarters for Precision," this statement appears:

> The Director of the Bureau, Allen V. Astin, showed me a letter from Maj. Gen. Bernard A. Schriever, Chief of the Air Force missiles program, thanking the Bureau for certain materials under rocket conditions—research that had effected an immediate saving of $4 million.

Could you tell me how that was brought about?

Dr. ASTIN. Yes; I would be very happy to.

In connection with one of the activities of our radio propagation laboratory we were studying the characteristics of the atmosphere which cause an apparent shift in position of an object when one used radio rangefinding techniques, and because of the data we developed about the characteristics of the atmosphere which cause an uncertainty in the position of an object when located this way, the Air Force was able to abandon one of the programs that they had initiated to achieve a particular weapons system; that is, these data enabled them to make a decision in advance without carrying the program through by a trial-and-error technique.

Now, to get into it further, I would get into the area of classified information.

Mr. ANFUSO. And do other agencies in the Defense Department consult you from time to time?

Dr. ASTIN. Yes, sir; they do.

Mr. ANFUSO. Do you feel as though you are properly equipped to meet this new space age?

Dr. ASTIN. Well, our 1960 budget request very specifically points out the inadequacy of our present equipment, and if our 1960 budget request is granted, it will be an important step forward, but a step only in achieving the modernization and additional equipment facilities which we need.

Mr. ANFUSO. Do we, Mr. Chairman, have anything to do with reviewing what the Bureau of Standards requires?

The CHAIRMAN. Well, the purpose of the hearing this morning was to get an idea of the general overall physical needs of the properties, and as that develops we will want to know their needs as to budget recommendations.

Of course that is the Appropriations Committee function, but we want to know—because we want to know as we go along how the work of the Bureau is progressing and what its physical needs are and how it is being handled—whether or not they are being met.

Mr. ANFUSO. The Bureau of Standards is mentioned specifically in the act which created this committee?

The CHAIRMAN. That is right.

Mr. ANFUSO. Therefore I think we would probably have the right to view the appropriations in advance.

The CHAIRMAN. Well, the way that is usually done, the committee is given a prebriefing on the needs, the budgetary needs, and I am sure that that will occur in the future.

This is a new committee and we haven't been able to do it. I think at this point it would be a fine thing to place in the record here a copy of this Reader's Digest reprint by Ira Wolfert entitled "Headquarters for Precision." It is a fine writeup of the work of the Bureau of Standards.

(The reprint follows:)

[From Reader's Digest reprint—condensed from Think]

HEADQUARTERS FOR PRECISION

What is a millionth of an inch, an ounce, a second? Without the answers provided by our extraordinary Bureau of Standards there would be chaos in our factories—and in our lives.

(By Ira Wolfert)

Behind the ivy-covered walls of the National Bureau of Standards in Washington, D.C., some of the weirdest machines yet devised by man drone and thump 24 hours a day. One measures the sound-transmitting characteristics of the human skull—to help solve hearing problems. Another pulls steel plate apart to find out why a ship sank. A third duplicates the strain of modern high-speed sewing, yanking thread from a standstill to 500 miles an hour in 1 second while a high-speed camera records the resulting loss of strength. For in situations involving fabrics—safety belts, tire cords, and parachutes, for example—human life can hang literally by a thread.

The Bureau of Standards plays a larger part in the daily life of every American than any other Government agency. It's a huge, swarming grab bag of activities. You cannot bake a cake, mail a letter, or drive an automobile without coming into contact with its work. The exact capacity of your measuring cup, the degree of stickiness on the back of the postage stamp, the octane rating of your gasoline were determined by the Bureau.

The Bureau of Standards was set up in 1901 by an act of Congress to provide standards of measurement when they "are not to be obtained of sufficient accuracy elsewhere." At that time chaos was standard. Electric bulbs and sockets came with 175 different size threads—why should a company make a socket that would enable a customer to buy a bulb from a competitor? Baltimore almost burned down in 1904 because the hoses of fire companies called in from neighboring towns to fight a huge blaze didn't fit the city's hydrants. In Brooklyn, N.Y., four different lengths were legally recognized as constituting the 12 inches of a foot, a fact which led to some interesting real-estate and property-taxation problems. The Bureau has no regulatory or administrative powers; yet now, largely because of its influence, almost all electric sockets have the same size threads, hose fittings and water outlets match all over the country, and a foot is a dependable unit of length.

The Bureau started with a $42,000 operating appropriation and a staff of 22. Today it employs 3,000 people, occupies 70 buildings, and can spend $42,000 in one

morning. It established the model inch, ounce, pint, and bushel, the precise second, the perfect volt, watt, decibel of sound, and candlepower of light—and these only scratch the surface. Now there are about 700 different standards, measuring not only things but energies, not only size, weight, and force but also quality. The Bureau calibrates the master gage blocks and other measuring devices by which these standards can be adhered to; without them, there would be chaos in our factories. It also prepares faultless samples of 600 different kinds of basic materials—such things as 100-octane gasoline, chemicals, steels. These make it possible for a steel mill, for instance, to check its product against the sample to see whether it is producing steel of the required properties.

In everything, the Bureau has one aim: absolute accuracy. I was taken to a securely locked vault to see "Kg20," the $3,000 platinum and iridium kilogram upon which all our weights are based. "Kg20" is never touched by human hands: a fingerprint would add to its weight. The Bureau has other kilograms in daily use, and periodically these are balanced against "Kg20" to make sure they have neither gained nor lost weight. The scale the Bureau uses is under glass to keep out the dust in the air; it is so sensitive that it must be operated by remote control, for the heat from a human hand 10 feet away could throw it off.

Why such fanaticism? Because we live and work surrounded by brutal perils. We cook with deadly gases. Murderous electric currents are frequently only a fingertip away. A smidgen too much radioactive iodine in a medicine could do us more harm than good. Modern science and technology are able to put these awful forces to work for us only if they are measured with the utmost precision.

One of the tasks of the Bureau is to measure the basic properties of metals and other materials at a wide range of temperatures and pressures. Now, for the space age, industry is thrusting materials into a whole new range. The Director of the Bureau, Allen V. Astin, showed me a letter from Maj Gen. Bernard A. Schriever, chief of the Air Force missiles program, thanking the Bureau for research on certain materials under rocket conditions—research that had effected an immediate saving of $4 million.

Bureau scientists have come up with many inventions of great commercial value. For example, the first alternating-current plug-in that put radio into the home, the magnetic fluid clutch, the first automatically sequenced high-speed electronic computer. The Bureau makes it research results and discoveries freely available to industry, and its patents are licensed without charge in this country.

Much of the Bureau's testing is to help the U.S. Government, the world's largest shopper, get the right quality of merchandise. In buying sheets for a VA hospital, for example, the Government uses the Bureau's specifications as to the number of stitches per inch in the hem, number of threads per inch in the material, and the breaking strength of each, and then gives the order to the lowest bidder whose product meets the requirements.

The uncanniest radio program on the air is broadcast by the Bureau over its two shortwave stations: WWV, Washington, and WWVH, Hawaii. When you tune in, you feel as if you're holding a stethoscope to some new, bewildering form of life. Twenty-four hours a day, year in and year out, the program features silence, puncturated by a ticking sound. At the end of 5 minutes a voice announces: "When the tone returns, eastern standard time will be * * *." It's a 600-cycle tone, and the dynamos in the Nation's power stations dance day and night to it. Engineers divide it by 10 and set their electric current alternating at the 60 cycles to which almost all our motors, appliances, and electric clocks are geared. At the end of the next 5-minute period the audible tone is at 440 cycles—A above middle C—for the benefit of musicians and the audio industry.

The ticking sound in the program is the heartbeat of much of our modern industrial life. Each tick marks a single second, a yardstick of incalculable importance. Momentous activities are controlled by instruments that measure time in hundred-millionths of a second and translate it into terms of distance. That's how radar works, how ships and planes navigate, how highway surveyors sometimes measure distances. To these instruments a fraction of a second means a fraction of 186,000 miles (the distance a radio impulse travels in a second), and no ordinary clock can come close enough for them.

How does the Bureau time tick come close enough? An electric current is passed through a set of 16 precisely tooled quartz crystals in an underground vault. The current makes the crystals pulse. A computer counts the pulsings, and then sounds a tick when a million have occurred. The quartz system is now being checked periodically against experimental atomic clocks. One is based on the fact that an atom in a certain molecule vibrates steadily at the rate of

23,870,100,000 times a second, and the computer will count its pulsings. Where the quartz crystals' pulse beat may vary 1 part in a hundred million, this atomic clock will not vary more than 1 part in a billion—1 second in 30 years.

In one of the Bureau's 100 laboratories I saw men toiling at the furthest frontier of the infinitesimal. The way to build a better refrigerator, pump, fuel injector, electric motor—almost any machine—is ordinarily no mystery to designers. The problem is how to get finer tolerances in mass production. The first automobile engines were manufactured to tolerances of one one-thousandth of an inch. To achieve that, men needed to set their calipers with gage blocks that were accurate to one ten-thousandth of an inch. Today engines are manufactured to tolerances of one ten-thousandth, and we feel the difference every time we step on the gas. Now industry wants tolerances of a few millionths of an inch. It will mean that wear and vibration will almost disappear as factors in engine performance, that the life of motors will be extended enormously.

But to get tolerances of such fineness means a gage block accurate to one ten-millionth of an inch—a nearly incomprehensible dimension. It is to one-sixteenth of an inch approximately what 1 inch is to 10 miles. The Bureau is achieving it by matching the block to a light wave whose length has been fixed by nature with superhuman accuracy.

It's an old saying in science that if you go deeply enough into even the simplest thing you come out ultimately in the universe. The men of the Bureau of Standards go so deeply into the inch, the ounce, and the second that this is where they are coming out—in the universe, taking our industrial society with them as they go.

The CHAIRMAN. May I ask you this, too?

What is your program and mission for this site that you have acquired in Virginia?

Dr. ASTIN. In Maryland, do you mean?

The CHAIRMAN. Gaithersburg, Md., yes.

Dr. ASTIN. Our program there was outlined a couple of weeks ago by Mr. Christeller.

But, briefly, we acquired a 500-acre tract there about 2 years ago, and the last Congress appropriated $3 million for the development of the architectural plans and specifications.

We are now very intensively engaged in this problem of designing the new laboratories, working with the architects, in order to try to achieve a facility which will really enable us much more effectively to meet our responsibilities.

We have no construction authorization at the present time, so it is impossible to give you any estimate on scale of completion, and I can't make any forecast of this because this depends upon the President's policy for new construction.

The CHAIRMAN. Sure. We are not trying to get you into a difficult position here, and I am trying to avoid that, but at the same time, we would like to get some idea.

You do have a construction program expected for the Gaithersburg site?

Dr. ASTIN. It will take about 4 years after construction money becomes available to complete the facility and move into it.

The CHAIRMAN. And in due course you will need the authorization from this committee, or at least you will need authorization from the Congress.

Dr. ASTIN. We are operating under the authorization of the Public Buildings Service for this purpose, that is, all of the construction moneys, when and if we get them, will be turned over to Public Buildings Service, and the laboratories would be built under PBS's authorization. At least that is the plan at the present time.

Mr. MILLER. Mr. Chairman.

The CHAIRMAN. Mr. Miller.

Mr. MILLER. I wonder if you could have someone out there, on an automobile road map, outline where your property is, and send it to the committee. Some of us drive out occasionally on Sunday, and we would like to take a look at the site.

Dr. ASTIN. Well, I would consider it a rare privilege to show you, but I can define it briefly.

Just this side of the Gaithersburg turnoff on Route 240 there is an underpass and an overpass, and our tract bounds this region between the underpass and the overpass on the left-hand side of the road going toward Frederick.

Mr. MILLER. I think I know about where it is.

The CHAIRMAN. Now, let me ask you this: Since you have got an architect and you are working on plans, can't you give us some idea what you are working on without committing anyone?

Dr. ASTIN. I could very well.

We could show you in as much detail as you wish.

We have site plans, sketches for the buildings, and I would be very glad to show you this whenever you wish.

The CHAIRMAN. Yes, just in an overall way.

As I say, we have a subcommittee that we want to go into the details.

Secretary OECHSLE. We could show that to the subcommittee when they visit the Bureau of Standards.

Dr. Astin could show them the plans for the building and give them an idea where the site is and give them a road map, if they wanted to drive out there over the weekend. We would be very happy to.

The CHAIRMAN. Mr. King.

Mr. KING. I would like to ask this question:

You have made much reference to the tests you conduct, testing material, and various things of scientific value which you pass on to private industry.

We have received testimony, of course, from private industry as to the tests that they are conducting, and we have received evidence from other governmental agencies of tests that they are conducting.

Now, my question is: Who decides what tests are to be conducted by whom in order that there be no overlapping and duplication, so that you will have 10 different Government agencies all conducting the same tests on the same materials?

Dr. ASTIN. Well, basically, it is my responsibility or my deputy's Dr. Huntoon's, to decide or to make the final decision on whether or not a particular job is done at the National Bureau of Standards. But our policy is to undertake no test at the National Bureau of Standards which can be performed adequately elsewhere; that is, we seek in general to encourage other organizations to develop their own test competence and do as much testing as they can. We may get involved in something occasionally in a referee's capacity or if the test is one involving the ultimate in precision, we may be the only ones that can do it. But in general this is the point of view we take on testing.

Mr. KING. Am I to infer then that you are aware of all of the tests that are going on pretty well?

Dr. ASTIN. No, sir; but we do try to keep abreast of testing activities and testing competence elsewhere.

Mr. Chairman, I had understood from discussions with your staff and also where, from reading the charter for this committee, that you were interested in the status of the basic measurement standards and also in the metric system, and I am prepared to make a discussion on this point, if you wish.

The CHAIRMAN. Well, I think that is all right.

Actually, the reason we asked the Secretary to come down here, though, was to give us an overall picture, because we don't have him often, and we wanted to get that overall setup while he was here.

Now, if he has nothing to add to what he has told us, then——

Secretary OECHSLE. I can't add anything more to my statement at the moment.

We will know sometime the latter part of next week. We have had our hearings with the House Appropriations Committee, and we will know at that time the action that they are taking on our National Bureau of Standards appropriation requests, and then beyond that——

The CHAIRMAN. Tell us what you have asked the Appropriations Committee for.

Secretary OECHSLE. Well, for instance, in 1959, the appropriation for the Bureau of Standards was $12,690,000. That was the 1959 appropriation, adjusted. And the 1960 estimate that we have requested is approximately $19,215,000 or an increase of $6,525,000.

Now, that is a considerable increase.

The CHAIRMAN. Now, what is that increase for?

Secretary OECHSLE. $4,910,000 of it is for research and technical services, and $1,715,000 of it is for plant and facilities.

The CHAIRMAN. What is the plant and facilities item for?

Dr. ASTIN. The major part of that is for this new wing at the Boulder Laboratories that I have referred to.

The CHAIRMAN. You have already explained that to us. That is a major portion of your request for funds, then. That gives us a little idea of what you are planning, anyway.

Secretary OECHSLE. Well now, I understand, at the hearing on May 8, our budgetary needs for 1960 were set forth in detail before this committee by our budget man at the Bureau.

The CHAIRMAN. That is right.

Now then, Doctor, if you will, proceed with what you have there.

Dr. ASTIN. Very good, sir.

As I indicated, the two items I wish to cover are the status of our English system of measurement and the status of the metric system.

Neither of these systems are at a position now where we wish to make legislative recommendations, but it is probable or quite possible that there will be some in the future.

As you know, our Constitution gives to the Congress the authority to fix the standard of weights and measures. This authority has been exercised very sparingly, and I have been able to find only one instance where the Congress has used this authority to fix clearly and unambiguously a basic standard for measurement. This was in 1828, when the Congress said that the standard weight for purposes of

coinage would be a specific brass weight which the Secretary of the Treasury had procured in England a year before.

This act was essentially repealed in 1911 when the Congress said that the standard weight for coinage purposes would be the standard troy pound of the National Bureau of Standards.

I think you would be interested in the general history of the status of weights and measures, and we have a circular of the Bureau in which this is summarized. I have copies available for each member of the committee, but in order to explain the current situation, it might be desirable to review briefly some of the things that are in this handbook.

In 1830 a Senate resolution directed the Secretary of the Treasury to explore the problem of standard weights in the customs houses and to make recommendations to the Congress.

In the course of this study, the Secretary of the Treasury made certain arbitrary decisions that certain items would be standard for their own purposes, and then in 1836, a joint resolution of the Congress directed the Secretary of the Treasury to provide a complete set of weights and measures adopted as standard to the customs houses and to the Governors of each of the States of the Union.

Now, this act did not say what the standard was. It uses the phrase, "adopted as standards," and infers a certain responsibility of the Secretary of the Treasury, I believe, to define these standards.

In 1866, the Congress passed a law legalizing the use of the metric system in this country, and defined metric values in terms of customary units in the United States.

Then in 1878, the Senate ratified the Treaty of the Meter by which this country agreed to provide support to the International Bureau of Weights and Measures. This Bureau has basic responsibility for maintaining, defining, and perfecting the metric system, and to some extent for encouraging its use.

As a result of our adherence to the Treaty of the Meter, we received copies of a standard meter and standard kilogram in 1890, and in 1893 the Superintendent of the Office of Standard Weights and Measures in the Treasury Department, issued an order defining the yard and pound in terms of these metric measures.

It is not clear to me on what authority the Superintendent of Standard Weights and Measures acted. Presumably, it could be developed from the authority in the joint resolution of 1936. But at any rate, this is essentially the situation as it exists today.

However, as you know, in 1901, the Congress established the National Bureau of Standards and authorized us to develop and maintain the standards for physical measurement and to provide means for their effective utilization.

We interpret this authorization as permitting us to extend continually and to refine the standards for measurement in order to make them meet the requirements of modern science and technology.

Now, the real legal status which our standards for measurement have in the United States is largely the status that the individual States gave to them. We have authorization from the Congress to cooperate with the States in promoting uniformity in weights and measures laws and methods of inspection, and operating under this authority we have developed a mechanism for bringing States weights

and measures enforcement officials together and developing uniform techniques and procedures for them to employ.

As a result of this, most of the States have quite similar weights and measures laws, and in essence all of these laws—or most of these laws I should say—look to the National Bureau of Standards to define through calibration the standards which are used for internal enforcement within the States.

Now we have encountered a situation in using the English system of measurements where the inch or the yard as well as the pound have different values in different parts of the English-speaking world. That is, our inch is longer than the British inch, and the Canadian inch is somewhere in between.

Now, these differences are approximately 2 to 4 parts in a million, and they are significant in very precise metrological work.

Now, the status of this problem of the difference in the values of the inches used in this country and elsewhere is summarized in a talk I gave before the American Ordnance Association a little over a year ago, and if you are interested for general background reasons, I have copies of that available.

But these differences in the inches and pounds used among the various countries have led to a problem in the interchangeability of very precise technological equipment among the English-speaking people.

Now, for this reason we have discussed this problem among the English-speaking people, and as a result of these discussions the Directors of the National Standards Laboratories in six of the major English-speaking countries reached an agreement to recognize new units which we call the international yard and the international pound. We have agreed among us that we will make all of our precise calibrations unless otherwise required in terms of these new international units, beginning on July 1, and copies of this announcement which was made last January are available for you.

Now we are currently in the process of determining what the other requirements may be for exceptions to using these international values for the yard and pound exclusively.

One exception we know of, and this is the requirement of the Coast and Geodetic Survey. Its entire system of mapping and surveying is based upon the value of the yard as defined in this order of 1893, which I referred to earlier. So there will be an exception made to recognize a U.S. survey-foot for this purpose for as long as it appears necessary for the Coast and Geodetic Survey.

Now, you may logically ask the question: Why do I not recommend to the Congress to define legally, once and for all, a standard value for the inch?

The reason for not doing this is that if I made such a recommendation at this time, I would have to ask you to define two standard values, one to meet the needs of the industrial economy in the interchange with the other English-speaking people, and the other to meet the requirements of the mapping people and the Coast and Geodetic Survey.

I think it would be inconsistent to do this in law. It is my hope that the Coast and Geodetic Survey ultimately will find it possible to convert to these values, and when this appears practicable, then we

will ask the Congress to provide us with a firm unambiguous legal definition for the inch and the pound.

The CHAIRMAN. Thank you, Doctor, very much.

That is a very scholarly address that you made to the American Ordnance Association in Bedford, Mass. I think it should appear in the record, so all of the members can study it.

Mr. King, you had a question?

Mr. KING. I have a couple of questions.

First, what is the historical basis for our yard and foot? Is it supposed to be geared theoretically to a dimension of the earth as is the meter, as I understand it?

Dr. ASTIN. No; the yard is basically related to the distance between the tip of the nose of one of the English kings and the end of his outstretched arm. This is the traditional source of the yard. But a few centuries ago this was recognized as inadequate, and the British did construct various metallic bars which provided the standard for the yard, and we obtained our standards from them.

Now, the British imperial yard was destroyed by a fire which destroyed the House of Parliament some time in the 1830's, and they were confronted with the necessity of developing new standards, and this I believe caused their yards to drift slightly from those that we had brought over here, because the yard which the Secretary of the Treasury adopted in 1836 as the standard was a brass scale which had been purchased by Hassler, the founder of the Coast and Geodetic Survey in England about 1813, as I recall. So this was the original status of our yard.

The nearest it got to having a legal status was by this joint resolution of the Congress in 1836, which implied an authority to the Secretary of the Treasury to define it, and he defined it for their use as a particular interval on this scale which he had. It was actually an 82-inch scale, and he defined the yard as the interval between the 27th and 63d inches of this scale. This was the situation that existed until 1893, when the decision was to base the yard on the meter, and the yard is now so defined. We look to a definition of the yard which is based on the meter, and we maintain no standard yard nor standard pound.

The CHAIRMAN. Mr. King.

Mr. KING. One other question:

In this country we still use long tons and short tons, nautical miles and statute miles, and other measurements we have two sets.

Now, why in the world should we have grown up with two sets? They are not too different. The long ton and short ton are of the same order. What possible purpose does it serve having two set standards, and would it be feasible to try to legislate to standardize that type of measurement?

Dr. ASTIN. I am not sure at this time that it would. The long ton has certain advantages because it is very close to the metric ton. That is, the long ton, as I remember it, is 2,240 pounds, which is very close to the metric ton. This is a convenience in approximate conversions of large weights between the two systems.

Now, I would like to say a few words about the metric system.

As I think you know, it was originally based upon a meter which was supposed to be one-ten-millionth part of the earth's quadrant.

It proved impractical to realize a precise meter from this definition. So scientists agreed, in working together, that this would have to be established in terms of an arbitrary definition based on an arbitrary length. It was this activity which led to the Treaty of the Meter in 1875, which we ratified in 1878.

The organization of the International Bureau of Weights and Measures, which has custody of the meter and the metric system, is governed by a general conference of weights and measures which meets normally every 6 years, with formally designated representatives of the adhering countries.

This general conference establishes an International Committee of Weights and Measures, an 18-man committee, with each member from a different country, which serves an executive function to supervise the activities of the International Bureau and related technical programs.

I am a member of this 18-man committee.

Now, this group, in 1889, defined the meter as the distance between two lines on a particular bar made of an alloy of iridium and platinum. This, however, is no longer adequate for modern requirements, and the International Committee of Weights and Measures, at a meeting in Paris last fall, agreed to abandon this definition of the meter and to base the meter upon the wavelength of a particular light radiated from the atom krypton 36. This recommendation will be voted upon in 1960 by the representatives of the nations that adhere to the Treaty of the Meter.

Now, there have been a number of other developments with respect to the meter.

As I have indicated, it is the only system of measurement generally authorized for use in this country by act of Congress.

We look to the meter to provide our definitions of the yard and of the kilogram and the pound.

The metric system is almost universally the system for expressing the measurements of science, and it is involved in many industrial measurements used to quite an extent in the electrical industry and in the chemical industry.

Now, within the last 2 or 3 years the pharmaceutical industry, on its own initiative, decided to go over completely to the use of the metric system.

Also, within the last few years, all of the remaining large nonmetric countries in the world, other than the English-speaking countries, have made the decision to go to the metric system.

The three specifically that have done it within the last few years are India, Japan, and Red China. This leaves now essentially only the English-speaking people not using the metric system in the world. Many people are becoming increasingly concerned with the increasing necessity for communication in technological terms with the rest of the world, and over possible handicaps we may encounter in these dealings by not being on the metric system.

In addition, there is the problem of foreign trade, where our industry is finding it increasingly difficult to compete in metric markets with products made in English measures. Particularly in terms of our economic competition with the Soviet Union, we are handicapped in

dealing with the rest of the metric world by the fact that we are nonmetric.

Because of this, the Secretary of Commerce announced a short time ago his desire and intention to seek means to accelerate the relative slow conversion in this country to the metric system, and he has asked us at the Bureau to set up an advanced planning group and to study ways and means by which one might accelerate this conversion to the metric system.

I am personally in the process of staffing this advance planning group and trying to develop appropriate suggestions for advisory committees to help us in this.

But one might approach this problem of conversion in a number of ways, that is, one might consider conversion of segments of science or activity; for example, one might consider conversion of temperatures measurements from the Fahrenheit scale to the Celsius scale, independent of anything else.

One might consider this before the length measurements. As far as machine tools are concerned, this creates a real problem. One might consider conversion of selected industries. The pharmaceutical industry has already decided to convert.

The radio industry might find it much easier to convert and thus possibly convert in advance of machine tool conversion.

There are other areas which might remain in their present status for generations, such as the mapping area, which I had mentioned earlier in connection with the inch problem.

This, I think, is a very important decision of the Secretary of Commerce. It is one which impresses me particularly with respect to the load it gives us in terms of developing recommendations and possible plans of action. This is most certainly an activity of which we want to keep this committee advised. If at any time it appears desirable to make recommendations for legislation in connection with this problem, we will be most happy to bring these matters to your attention.

The CHAIRMAN. Thank you very much, Doctor.

Are there any questions?

This has been a very learned discussion.

Mr. FULTON. The question comes up: Why don't we just take a point and say that we in the United States will be on the metric system, and set the point far enough ahead in time that people can work toward it and prepare and then have this committee have legislation which takes that revolutionary step for the country and cuts the Gordian knot once and for all?

When I started out in Congress 15 years ago, I was on the original Coinage and Measures Committee, and I always wondered why we stayed with this rule of thumb and rule of arm designation when it had gotten to the point where we were trying to convert into mass, temperature, energy, and various things, measurements that are very difficult.

Several companies are operating in Europe that have had a tremendous problem getting their diagrams and specs into shape for bidding purposes.

I have a Foreign Affairs Committee meeting in 27 minutes, and with the chairman's permission, may I say we have never had an exact method of correlating earth measurements and distances from one

agreed point on the earth's surface or from a scientifically agreed center point.

We have never had a method of measuring siderial or astronomical time from a point easy to state mathematically in current time usage. We have never had an exact designation of the first point of Aries at the vernal equinox. It is now necessary to have a bridge developed between exact earth measurements of time and distance with those of outer space.

We actually don't know how far we are from any point on or in the earth or space or how long we are from a standard point of reference in time.

I am proposing to prepare a resolution to provide a basic standard for measurement of time and distance in relation to the earth and outer space so that the standards of the two systems are exactly correlated and integrated. We can then move from an exact point in time and location on earth to time points and distances in space.

That is what I wanted to say earlier.

Is that understandable?

Dr. ASTIN. Yes, very.

We would be glad to take that as a guide to develop recommendations.

The CHAIRMAN. Thank you very much.

Whom do we have now? Do we have Dr. Wichers?

Dr. ASTIN. Dr. Wichers, our Associate Director for Chemistry, is also in charge of coordination of our international activities, and at our earlier appearance here a question had been raised about the international activities of the National Bureau of Standards, and Dr. Wichers is prepared to talk about those.

The CHAIRMAN. Fine. We would be happy to hear from him.

I am going to say this: I have a meeting at the Capitol at 20 minutes to 12, and I am going to ask Mr. Hechler to preside.

I will be back as soon as that meeting is over.

Mr. HECHLER. Dr. Wichers, do you have a prepared statement?

STATEMENT OF DR. EDWARD WICHERS, ASSOCIATE DIRECTOR FOR CHEMISTRY, NATIONAL BUREAU OF STANDARDS

Dr. WICHERS. Mr. Chairman, because of the nature of its work, the National Bureau of Standards has many contacts with other countries. Some of these are on an organizational basis and some are on a personal or individual basis.

The Director has already spoken of the formal organizational relations with the International Bureau of Weights and Measures, and in dealings with other countries such as those of English-speaking countries in definitions of units of length and mass.

There are many other formal organizational ways in which the Bureau has dealings with other countries. There are a number of international scientific unions, such as the Scientific Radio Union. There is a union of mathematics, a union of astronomy, and so on.

In most of these, members of our staff take part in the international standardizing activities and in the exchange of technical information.

I might cite as one example a piece of work we have recently completed at the request of the commission of the International Union

of Chemistry. This had to do with means of improving the evaluation of the composition or, more properly, the purity of substances by a certain technique of physical measurement which was pioneered at our Bureau some years ago and has now come into important industrial use.

The commission held a symposium in Amsterdam a few years ago at which variations in the procedure were discussed, and the conclusion was reached that, in order to have uniformity for this type of vaulation, some standard material should be prepared which could then be measured in a number of laboratories and the results compared to see what the state of the art is.

This work has been completed. We have distributed 30 samples to all of the laboratories interested in participating, and within months we hope to compile the results and make a critical evaluation of the series of tests, after which a report will be made to the International Union of Chemistry.

This is one illustration of the way in which the Bureau functions in such organizations.

These unions have periodic meetings, at intervals of 2 to 3 years, and the Bureau recently has been host to two such meetings.

One was the international scientific radio meeting, held at Boulder in late 1957.

Another was a meeting of the International Commission for Uniform Methods of Sugar Analysis. This seems a highly specialized thing, but sugar is an important article of international commerce and this commerce requires assays of raw sugar. For 40 years now there has been international activities in which the United States, through our Bureau, has been very active in standardizing these methods of sugar analysis. About a year ago, this time, the Commission met at our Bureau in Washington.

There is a federating scientific organization called the International Council of Scientific Unions, which is a sort of sponsor for all of these specialized unions. This International Council of Scientific Unions will also take responsibility for scientific and technical activities that cross the specialized union lines.

An example of this has been the sponsorship by this Council of the scientific work involved in the International Geophysical Year.

There have been other activities dealing with oceanographic research, polar research, and so on.

Our Boulder laboratories in particular took a very considerable part in the activities related to the International Geophysical Year that were sponsored by this Council.

There is another international organization called the International Standardizing Organization, which deals with standards for commodities largely— quality standards, performance standards, and things of this kind.

There the official participation in this country is through a private organization called the American Standards Organization, with which, however, various parts of our Bureau have considerable to do.

Now, I should like to turn to the exchange of information on a personalized basis.

First of all, just briefly, I would mention the exchange of the Bureau's scientific publications with similar publications in other countries.

There are currently some 521 such exchanges with 46 countries. There also is much exchange of information by correspondence, but I would like to talk particularly about exchanges that occur in visits.

In 1958, the Bureau entertained about 1,000 visitors, foreign visitors from 50 countries. Of these, 285 came as teams, in 27 teams sponsored by the International Cooperation Agency of the State Department. This leaves some 700 who came as individuals or sometimes in groups of two, seeking information on their own account, not sponsored by any agency, such as the State Department.

More than half of these came from six countries. For example, there were 95 such visits from England, 105 from Japan, and so on—even 25 from Australia.

This kind of thing, of course, also goes in the other direction. Members of our staff visit other countries in search of information and also to attend the meetings of the organizations that I have spoken of. But I think you will be interested to know that the flow of information in this case is predominantly outward, because the ratio of our people visiting abroad is only about one in five to visitors coming to us from foreign countries.

The predominance of this outward flow is not without some important exceptions. For example, we have had in the past year a very real benefit from a stay for 6 months of a scientist from Australia who had developed a new method of standardization that is of concern in the electronics industries, particularly in radio propagation.

This man had developed a scheme, the Bureau became aware of it, and in due course invited him to come to the Bureau, which he did, and there assisted our own staff in the improvement of this particular electrical standard.

The recent authorization by the Congress of sending staff members to other institutions for advanced training has been especially useful where this allows us to send people to laboratories and universities in foreign countries which often have facilities and competence not to be found in our country.

Currently, we have two or three people taking advantage of this in foreign universities.

In addition to these casual visitors, I speak of the 1-day—most of these have been 1-day or 2-day visits—we had in 1958, 28 guest workers from 13 foreign countries whose schedules called for stays from 6 months to 3 years.

Currently, in 1959, to date, we have 21 such guest workers. These are people who are capable of scientific work without supervision, and work side by side with our own scientists.

The areas of work have included solar physics, building technology, and in one case, work in dental materials.

Mr. HECHLER. Dr. Wichers, have you had any requests from scientists of Iron Curtain countries to get over here?

Dr. WICHERS. We have occasional visits from these people, but these have to be specially cleared by the Department. We have not had extended visits from the Iron Curtain countries, nor have we had people for training from them.

Mr. HECHLER. You are satisfied your security procedures are sufficiently tight?

Dr. WICHERS. Yes; and such visitors are under constant escort when they are in our buildings.

Mr. HECHLER (presiding). Proceed, sir.

Dr. WICHERS. Besides the guest workers, an important aspect has been the training system sponsored by the International Cooperation Agency and the United Nations.

In fiscal 1959 we had eight such trainees. These are people not competent to do independent work but who come here for specific training in our field.

We have just concluded such a period of 6 months' training of two young men from Mexico, who came here to learn matters concerning the inspection of weights and measures and the measurement of electrical units.

These young men are this week returning to Mexico, to their national laboratory, where they will certainly have a much greater competence than they had before, and might now possibly serve as people who will train similar people from other Latin American countries.

An important example of the advantages to be gained from having the trainees occurred a few years ago when we had two men from India who came to be trained in the production of optical glass and who returned to their country. Some months ago we learned that they had actually succeeded in beginning the production of optical glass in India.

This got wide recognition in India as an important accomplishment, and we have clippings from Indian newspapers in which this is referred to as a brilliant accomplishment—the first time in any Asian country in which optical glass has been produced. The incidental reference to the fact that this accomplishment was the result of training of Indian technologists in the United States would now make it unnecessary to accept the offer of Russia to provide training to India in the production of optical glass.

I am mentioning now statements that appeared in Indian newspapers.

There was one further consequence of this: Two or three years ago the Bureau determined that it would go out of business in the production of optical glass, since the American industry is now quite capable of handling the needs, and some surplus equipment has been transferred to India through the ICA.

In the last 5 years, members of the Bureau staff have made six in-country surveys of the needs for standards laboratories. These were in Turkey, Greece, Ethiopia, Costa Rica, Israel, and Guatemala.

Currently, one of our staff members is in Israel for a period of 3 months to help set up an acoustics laboratory.

There is just one other aspect of our international work that I want to refer to, and that is the purchase by foreign countries of the standard materials that the Bureau prepares and issues, largely, of course, for use in this country.

In the last fiscal year some 40,000 specimens of standard materials were sold. These are materials that are certified either with respect to their chemical composition or to some physical property of interest, such as melting point or refractive index.

Of this total, about 10 percent went to foreign countries.

Again, I might just use one illustration of how this works.

We have a material called benzoic acid, which has a certified heat of combustion by which fuel calorimeters, devices to determine the heating values of fuels, coal and other fuels, may be determined.

These must be calibrated, and standard benzoic acid serves that purpose.

In Holland it was learned that the material they had been using, a commercial preparation from Germany, gave a different result from the one they got with our standard material. They thereupon decided that henceforth all of their standardization would be in terms of our standard sample.

This increased considerably the load on this particular material, and we are now in correspondence with them in the hope that we may help them to set up a source of supply of standard benzoic acid in their own country.

In the course of this, we quite readily learned what was wrong with the German material. It was quite a simple point, and I think that we now may be in a position to aid the Dutch in setting up their own source of supply and thus lighten the load on our supply.

I think, Mr. Chairman, that this is all that I want to say at this time.

Yes, there is one other point that I should mention.

This has to do with Latin America, our cooperation with the Latin American countries.

There is an Organization of American States, as you know. This has a Committee on Standards. This Committee called a meeting in Rio a couple of years ago to look toward the development of inter-American standards which would promote inter-American trade.

Our Director for Engineering, Dr. McPherson, was the head of the U.S. delegation of eight persons who attended that Congress.

Mr. HECHLER. Thank you, Dr. Wichers.

Mr. Moeller.

Mr. MOELLER. Doctor, I think it is a tribute to your Department to have your facilities or merchandise, if you may call it, wished for by these foreign countries, that they want to buy it and make use of it as standards for themselves.

Secondly, you made mention of the thousand visitors here, and 105 were Japanese. Were these scientists?

Dr. WICHERS. Yes.

Mr. MOELLER. Now, will you tell us what caliber of scientists you thought these Japanese people were?

Dr. WICHERS. Well, the Japanese select their visitors over here with a great deal of care. I think, with few if any exceptions, these people are of high competence in their specialized fields.

Japan is working very fast to reestablish itself as a highly industrialized country, with very expert technology.

Mr. MOELLER. Just yesterday we heard from the Immigration Department, and among other things, I think questions were raised here to indicate that some people cast a bit of doubt on the efficiency of some of these orientals, and I am glad to hear this.

Dr. WICHERS. As far as my experience goes, these are people of very high standing.

Mr. HECHLER. Are there any other questions?

Mr. Chenoweth.

Mr. CHENOWETH. Doctor, I appreciate your reference to the laboratory at Boulder, Colo.

We are very proud in Colorado of that laboratory.

I think you have been expanding it from time to time. We recognize the importance of that laboratory to your work and to the Bureau as a whole.

I wanted to ask you, Doctor:

Do you have any information on the situation in Russia? You mentioned the scientists and others who are coming to this country to get information from you. Do you have any information on whether they are making similar pilgrimages to Russia to get information on similar subjects?

Dr. WICHERS. I do not have very exact knowledge or information on that, sir.

My impression, however, is that Russia welcomes such visits, and there actually are a great many. I know that Russia now sets up a great many international scientific meetings and invites people by name, in addition to the broadcast invitation to scientists all over the world to attend these meetings.

It frequently makes name invitations. One of our staff had such an invitation a year ago.

Mr. CHENOWETH. Do we participate in those meetings?

Dr. WICHERS. Yes.

Mr. CHENOWETH. What reports do they bring back?

Dr. ASTIN. I might refer to two instances.

A number of our staff members participated in the meetings of the International Astronomical Union and the meetings of the International Geophysical Year people in Russia last summer, and they have all come back and reported on their observations.

In general, the level of technical activity is very high. In some areas it may be in excess of our own competence; in others it is below, but in general there is a fairly good estimate by our people of the level of Russian competence.

Now, one of the Russian visits we had fairly recently was a team of electronic computation experts who had been brought to this country, and they spent part of a day at the Bureau, and one of our staff members will be a member of the exchange team; that is, this is a sort of one-for-one arrangement, and our staff member will go over there, and I hope will be able to report back on the competence of their work in this general area.

Mr. CHENOWETH. Do you feel that these exchanges are helpful and should be encouraged?

Dr. ASTIN. They are extremely helpful.

Mr. CHENOWETH. One hears so much about the possibility that Russia is exceeding us in the scientific field, in the missile field, and the exploration of space. I am curious to learn what your reaction is to those reports. I personally have not been able to subscribe to them, and I have not seen any particular evidence before the committee that that exists, but we always are hearing about it constantly.

Dr. ASTIN. Well, there is one area in particular that has given us a great deal of concern. I am not sure that I mentioned it to this committee when I was here 2 weeks ago. I know I mentioned it to

the Appropriations Subcommittee, but this is in the area of techniques for measuring very high temperatures.

Now, one of the techniques for doing this is called photoelectric pyrometry. We have not yet had an opportunity to examine directly what the Russians are doing in this area. We have some information from published reports but we did have visits last year, one from a Frenchman and one from an Australian who had seen the Russian work in photoelectric pyrometry, and both said without question it is far and away the best work of this kind they have seen anywhere. I remember particularly the plea of the Australian. He said "Good heavens, I am alarmed at their advanced state in this area. The western free world must catch up. The only country with a chance of doing it is you folks and you ought to get on the ball and try to do it," and we are trying.

Mr. CHENOWETH. That is a very interesting observation, Doctor. I do think on the whole we are holding our own pretty well with Russia in this scientific development program.

Dr. ASTIN. Well, I am not too happy. If one compares the present status of things we can say we are pretty well all right, but if one compares the rate of growth, that is in terms of the number of new scientists and engineers they are training each year compared to the number we are training, then frankly I am worried.

Mr. CHENOWETH. How does the quality compare?

Dr. ASTIN. This is difficult to evaluate, but all indications we have are that the quality of their training is quite high.

Mr. CHENOWETH. Do you feel then that they have programs that are going to test our mettle here and there should be incentive for us to go forward and do as much as we can?

Dr. ASTIN. That is correct.

Mr. CHENOWETH. Thank you very much.

Mr. HECHLER. Does Dr. Birnbaum have a statement? The hour is getting late.

Dr. ASTIN. We would be happy to have Dr. Birnbaum's statement submitted as a report for the record. This deals with our information on publication activities and we can submit this as a statement for your record if you like.

Mr. HECHLER. That would be fine without objection.

(The information follows:)

The major output of the Bureau is scientific information, tables of technical data, and papers describing the results of Bureau research. The major publication of the Bureau is the Journal of Research, a monthly scientific publication which has earned for itself a good reputation for contributing to the advance of science and technology. Starting this July the Bureau plans to expand this publication into four sections dealing with physics and chemistry, with mathematics and mathematical physics, with engineering and instrumentation, and with radio propagation. In this way we hope to reach more directly the technical audiences for whom Bureau research is primarily intended.

In addition to this major periodical, the Bureau issues a monthly periodical called the Technical News Bulletin. This is a digest publication designed for technical and trade publications, research management, and technologists. It summarizes and highlights the current work of the Bureau's scientists. The Bureau also issues a number of nonperiodicals on subjects resulting from Bureau programs such as the publications in the applied mathematics series, principally mathematical tables of interest to applied scientists and engineers, handbooks, giving data on safe practices, and monographs and circulars on various subjects. Finally the Bureau's Boulder Laboratories issues regular basic radio predictions

which, very much like weather forecasts, predict atmospheric conditions for radio transmission.

These are all the publications of the Bureau. You will note that they deal with technical material. They do not deal with consumer information or proprietary products. Our primary audience is the scientist, the engineer, and the technologist. These, using our information, are in a better position to serve the community.

Most of our information is published not in Government publications but in the publications of professional societies. We encourage this as the best means of disseminating our information and getting our results into use. Last year we published 264 articles in Bureau publications and 388 articles in professional scientific journals.

In addition to this means of data dissemination, it should be noted that our scientists participate actively in the meetings and programs of the scientific societies, and they are encouraged to do so. We are proud of the fact that many of our scienists serve on the managing and editorial committees of these professional organizations.

Before leaving the area of publication, I might mention that the Bureau issues a number of reports giving the results of Bureau work for other Government agencies. These are reports on work requested and paid for by another Government agency. It is work done usually under rigid and specified conditions and more often does not have general applicability. We do not consider these reports as publications but as communications to the sponsor. When these reports do contain information of permanent and general value they are incorporated into the Bureau's formal publications. The sponsor, if he wishes, may give these communications broader circulation.

Finally, I would like to state that we publish an annual report of Bureau activities. I am pleased to report that this past year we redesigned it, and it has sold out within 3 months of issuance and a second edition is being considered by the Government Printing Office.

The Bureau's library is one of the finest technical libraries attached to a laboratory. It contains about 80,000 volumes and is actively used by the Bureau staff and provides a good service through the interlibrary loan program. About 1,700 periodicals are available in the library. Two-thirds of these are foreign periodicals. We exchange publications with more than 46 other nations. We do not have an active translations program but do participate in the Government share program of translations being coordinated through the Office of Technical Services.

On our own we maintain a roster of the language facility of our scientists and using our talents are usually able to translate foreign scientific language articles which come to our attention but which have not already been translated elsewhere.

Mr. MOELLER. Mr. Chairman, may I ask another question?

The photoelectric pyrometry is a device for measuring the intensity of heat, did you say?

Dr. ASTIN. "Pyrometry" is the word used for heat measurement, photoelectric describes the technique, involving optical and electronic methods. The area is one primarily of identifying and measuring very high temperatures, that is, in the region of several thousand degrees. We are putting considerable effort on this area ourselves, but as far as we can determine and according to the advice or the evaluation that these outsiders gave us, we are behind the Russians in this area, very definitely.

Mr. HECHLER. I might say if the committee would care to foment a quiet revolution and adopt the metric system, the Chair would note we perhaps have a majority. I want to thank you, Mr. Secretary, and gentlemen, for testifying before the committee this morning.

The hour of 12 having arrived, the committee stands adjourned.

Dr. ASTIN. Thank you, sir; we enjoyed being here.

(Whereupon, at 12 noon, the committee was adjourned.)

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